The Branner Geological Library

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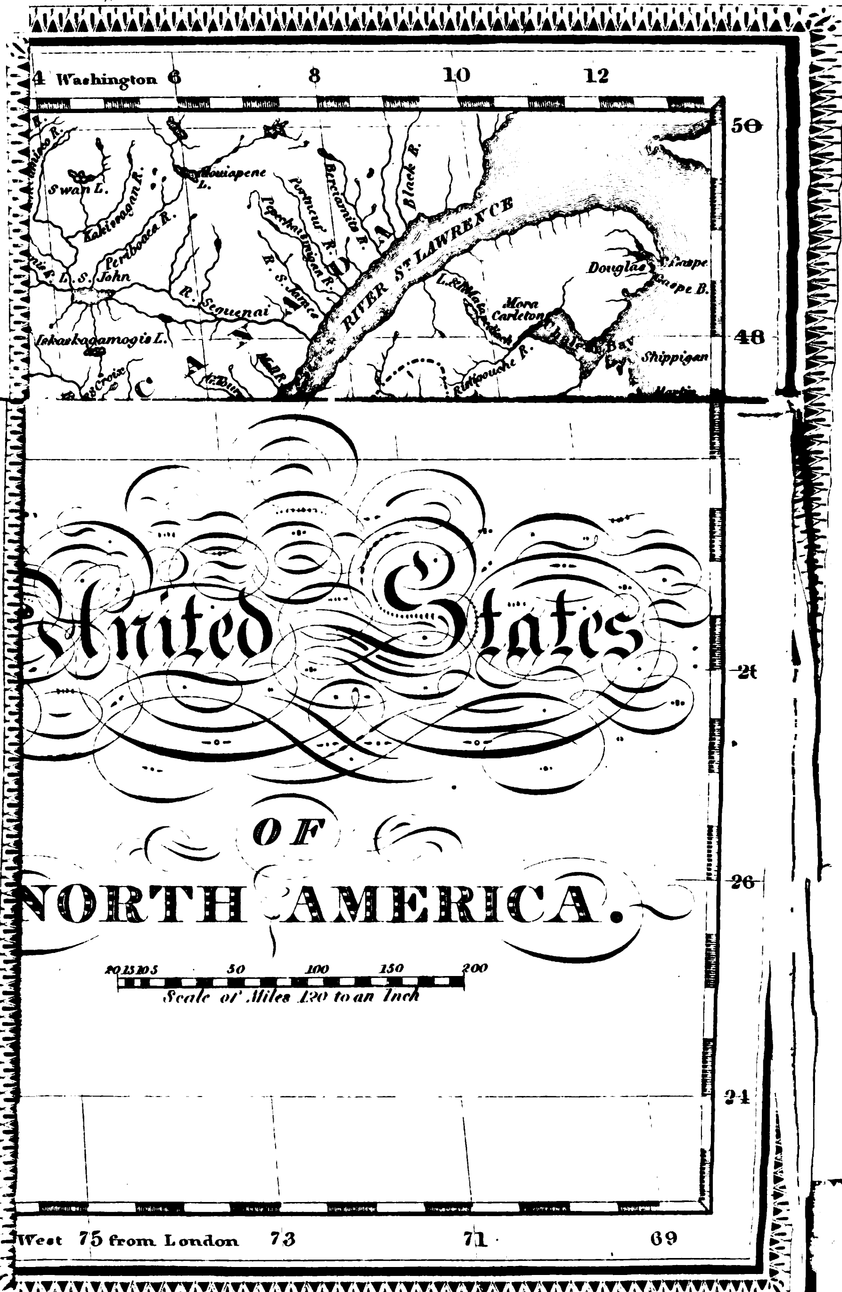

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OBSERVATIONS

ON THE

GEOLOGY

OF THE

UNITED STATES OF AMERICA;

WITH

SOME REMARKS

ON THE

EFFECT PRODUCED ON THE NATURE AND FERTILITY OF

SOILS,

BY THE DECOMPOSITION OF THE DIFFERENT

CLASSES OF ROCKS;

AND AN APPLICATION TO THE FERTILITY OF EVERY STATE IN THE UNION, IN REFERENCE TO THE ACCOMPANYING GEOLOGICAL MAP.

WITH TWO PLATES.

BY WILLIAM MACLURE.

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1817.

OBSERVATIONS

ON THE

GEOLOGY OF THE UNITED STATES.

PREFACE.

All inquiry into the nature and properties of rocks, or the relative situations they occupy on the surface of the earth, has been much neglected. It is only since a few years that it has been thought worth the attention of either the learned or unlearned; and even now, a great proportion of both, treat such investigations with contempt as beneath their notice.

The Germans were amongst the first who began to make accurate observations in this branch of science. Werner reduced the nomenclature to some regular form, and founded his system on the relative situations of the different classes of rocks. Although subject to all the errors inseparable from systems founded upon a speculative theory of origin, the system of Werner is still the best and most comprehensive that has yet been formed.

Why mankind should have so long neglected to acquire knowledge so useful to the progress

of civilization—why the substances over which he has been daily stumbling, and without whose aid he could not exercise any one art or profession, should be the last to occupy his attention —is one of those problems, perhaps only to be solved by an analysis of the nature and origin of the power of the few, over the many.

The science of Geology, until lately, has been confined to speculative theories on the origin and formation of the earth. Whether they have made any progress toward the discovery of that hidden mystery, or whether the last theory is nearer the truth than the first, is difficult to decide; for we have no data, no scale by which we can measure their relative merits. Each new theory is ushered in, by its author attempting to refute all former theories; but it is still doubtful whether success will repay the labour of so many men of brilliant imaginations, who have exerted their talents to make the discovery of the earth's origin. Meanwhile, the useful application of the substances found on the earth's surface, to arts, manufactures and science, has been rapidly progressing in proportion to the increase of positive knowledge; following in this respect, during great part of the last fifty years, the usual steps of rational civilization.

In all speculations on the origin, or agents that have produced the changes on this globe, it is probable that we ought to keep within the boundaries of the probable effects resulting from the regular operations of the great laws of nature which our experience and observation has brought within the sphere of our knowledge.

When we overleap those limits, and suppose a total change in nature's laws, we embark on the sea of uncertainty, where one conjecture is perhaps as probable as another; for none of them can have any support, or derive any authority from the practical facts wherewith our experience has brought us acquainted. The equator has been supposed to have been once where the poles are now, to account for the bones of the animals now living near the tropics being found in the higher latitudes; yet without any change either in the poles or equator, it is certainly not impossible but even probable, that these animals, before their tyrant man obstructed their passage, might migrate to the north during nearly three months of the summer; and might have a sufficient quantity of heat, and a much greater abundance of nourishing vegetable food, than the torrid zone could afford them at that season.

There does not appear to be any thing either in the climate or food that could prevent the elephants, rhinoceroses, &c. from following the spring into the north, and arriving in the summer even to the latitude of 50 or 60 degrees, and retiring to the warmer climates on the approach of the winter; on the contrary, it would appear to be the natural course of things, and what I believe our buffaloes in the uninhabited parts of our continent still continue to do; that is, to migrate in vast droves from south to north, and from north to south, in search of their food, according to the season.

The birds and the fish continue their migra-

tions, passing by roads out of the reach of man; the natural change of place which their wants require, has not been barred and obstructed by the united power and industry of the lords of the creation.*

To specify the many practical advantages arising from the knowledge of the nature and relative positions of the rocks which cover the surface of the earth, would require volumes. Here, it is only proposed to mention a few, which almost every man, during some period of his life, may find the necessity of resorting to.

First, from the knowledge of the relative situation of rocks and from an accurate investigation of the usual succession of one species of rocks to another, we are guided in our search for coal, gypsum, salt, limestone, millstones, grindstones, whetstones, &c.; as well as the probable places where to look for all kinds of metallic veins and repositories: for example, coals have not been found under any species of primitive rocks; of course, we should not look for them in that class, and if when digging for coal, we should come to the primitive rocks, we should desist. Coals have not been found

* Until lately we have restricted nature to two modes of acting; by fire, and by water: now, it is found, that she can change and metallize rocks in the dry way, without any solution or fluidity; and the galvanic pile may be formed in the stratifications of a mountain, as well as in a chemist's laboratory. These are two other modes wherein we must now allow her to change and modify the surface of this earth; and who can say how many more means yet unknown, she may possess? each of which, when found out by accurate and impartial observation, must make a change in former theories.

in any profitable quantities under any considerable bed of limestone, &c. &c. Wolfram accompanies tin in the greatest part of the tin mines; of course the appearance of wolfram is a sign, that most probably tin may be found in the vicinity, &c. Great sums of money have been lost in the United States, and in other countries, by digging for substances among classes of rocks, which have never been found to contain them elsewhere; and of course the probability was against their being found in that class of rocks here.

A knowledge of the nature and properties of rocks, and the results of their decomposition, enables us to judge of their hardness, easy or difficult decomposition, their component parts, mode of splitting, &c. by which we judge of their fitness for house buildings, roofing, road making, burning for lime, china or pottery, brick making, glass making, hearths for forges and furnaces, &c. We likewise know, by previous experience, the nature and richness of any metallic ore that may be found, and can calculate from the expense of procuring any ascertained quantity, whether the mine will pay for the working. It is thus we may avoid the losses of digging for species of ore, such as pyrites, that is worth little or nothing; as well as expending money in working a mine that was not rich enough to pay the labour. Much money might be saved by this kind of knowledge, in road making, where it frequently happens that a rock, such as limestone, slate, serpentine, &c. which would not perhaps last three months, is

taken in preference to a quartz or hornblende rock, that would wear one or two years. Expense is often incurred by making and burning bricks, that are useless from the clay containing too great a quantity of calcareous matter; or of burning lime when the stone attempted to be burned contains too little of calcareous, and too much of argillaceous or other foreign matter, which prevents it being reduced to quicklime; all which, the proper application of a small quantity of acid might prevent.

It may be objected, that there are professional men who will give advice on these subjects, on better terms than we can acquire ourselves the necessary knowledge; but it is sometimes the case with all kinds of counsellors, that they are more interested in the profits of the process, than in the profits of the result: and when it is considered, that less than half the time necessary to give a smattering of any of the dead languages at our academies, would be more than sufficient to give our youth a complete knowledge of the common and useful applications of earths and rocks, we may reasonably hope that ere long some portion of time will be appropriated in our colleges and universities, to studies of undisputed utility; and that a knowledge of substances, their properties and their uses, will be permitted in some degree to encroach on the study of mere words. The time seems fast approaching when what is called learning will not in all cases be deemed, as it has been in too many, synonymous with knowledge.

The greatest part of the first and second chapters of these observations was published in the sixth volume of the Philosophical Transactions, at Philadelphia, with the geological map. This was afterwards translated into French, and published in the Journal de Physique, for February, 1812, accompanied also by a geological map; since which we are indebted to the active attention of Dr. S. L. Mitchill,* for the only correction that has since been made, which consists in extending the alluvial over the whole of the east end of Long island, whereas we had supposed that the alluvial of the northern skirts of the island had rested on primitive. During an excursion last summer, an opportunity was afforded of ascertaining and extending the limits of the transition in the states of Pennsylvania and New York, as well as the boundaries of the great primitive formation, north of the Mohawk; and fixing the limits of the transition on Lake Champlain and in the state of Vermont with more precision.

The third and fourth chapters, are an attempt to apply Geology to agriculture, in showing the probable effects the decomposition of the different classes of rocks may have on the nature and fertility of soils. It is the result of many observations made in Europe and America, and may perhaps be found more useful in the United States than in Europe, as more of the land is in a state of nature, not yet changed by the industry of man.

* Dr. Bruce's Mineralogical Journal, vol. i.

CONTENTS:

OBSERVATIONS, &c.

CHAPTER I.

General Remarks on the Method of pursuing Geological Researches, with a few Observations on the different Chains of European Mountains, compared with those of the United States of America.

THE examination of the different substances which cover the exterior of the globe, may be commenced and pursued in two ways, both leading to the same point, though by opposite roads. The *first*, beginning by an accurate investigation of a small portion of the surface, describing exactly the different rocks, with their immense variety of arrangement in the position of their component parts, detailing the changes accidental or natural constantly occurring in their relative situation, and endeavouring to reduce the whole into some regular series of arrangement. This method necessitates the reunion of a great number of those portions, before any correct general ideas can be formed.

The *second*, beginning with the great outlines, traces the limits which divide the prin-

cipal classes of rocks, and their relative situations and extents; leaving the examination of the vast variety, contained in each class, to be regulated by the general principles previously acquired.

The method founded on accurate observation, though limited in extent, would appear to be the best, and confirmed by the practice of acquiring all the other sciences; and yet on a further examination, there are serious objections arising from the difficulty of the execution, on account of the great variety and imperceptible shades of gradation from one kind of rock to another; which would render the nomenclature extensive and intricate, necessitating long and voluminous descriptions, conveying imperfect ideas, that rather fatigue than instruct: for example, it would require a volume to describe all the varieties of rocks found in a range of forty leagues of the primitive formation; and in two leagues, either to the right or left of the same range, the changes would fill another volume.

In tracing the outlines of the different formations in most countries, there is less confusion and embarrassing description necessary; the limits once ascertained, a few pages define the boundaries, and explain the relative situations to the comprehension of every reader. For example: in the north of Europe, Norway is primitive with a few exceptions, the greatest part of which is the basin surrounding Christiania, which is transition. Sweden is primitive, except the southern part in Scania, and part of

the coast of the Categat, with some of the borders of the great lakes, which are secondary. Both sides of the gulf of Bothnia to the North cape, and from thence through Finland to St. Petersburg are primitive. From St. Petersburg to the secondary limestone of the Crimea is alluvial, except in three places, a narrow bed of chalk at Sewsk, twelve posts south-west of Tula, between Bogouslaw and Corsoun, eight posts south of Kiew, and from Elisabethgrad four posts to Wodinaria, where the primitive appears in the beds of the rivers. The secondary limestone of the Crimea is succeeded by the transition, about one and a half league south of Simphiropol, and the whole range of mountains along the Black sea on the south side of the Crimea is transition.

The south side of the Baltic is an extensive alluvial formation, bounded in Poland by the secondary limestone at the foot of the Carpathian mountains, in Silesia and Saxony by the edge of the secondary limestone that covers the foot of the Bohemian mountains, and so along the Thuringwald and Hartz to the North sea. Between these mountains and the Baltic, is one continued plain of alluvial with few or no exceptions, the exact limits of which would be easily ascertained, and still more easily described, to the understanding of every one; even the omission of some exceptions would not materially affect the utility, as they would be rectified by the next observer.

Another inconvenience seems to arise out of the method of examining minutely a small por-

tion, or part of one range of mountains, and that is the formation of a system which, though according exactly with the structure of the country examined, is too often in contradiction with the nature and formation of most others; tending in very many cases to perplex the reader, and throw the whole into discredit. In the present state of geological knowledge, an accurate definition of the rocks, commonly found united in great and extensive masses, with the limits of separation between them and rocks of the other great classes or formations, might perhaps be the plainest and most certain mode of increasing our knowledge, correcting the errors of the vast number of old, and throwing more light on the formation of new systems.

The short period of time that mankind seem to have been capable of correct observation, and the minute segment of the immense circle of nature's operations, that has revolved during the comparatively short period, renders all speculations on the origin of the crust of the earth mere conjectures, founded on distant and obscure analogy. Were it possible to separate this metaphysical part from the collection and classification of facts, the truth and accuracy of observation would be much augmented, and the progress of knowledge much more certain and uniform; but the pleasure of indulging the imagination is so superior to that derived from the labour and drudgery of observation—the self-love of mankind is so flattered by the intoxicating idea of acting a part in the creation—that we can scarcely expect to find any great

collection of facts, untinged by the false colouring of systems.

The peculiar structure of the continent of North America, by the extended continuity of the immense masses of rocks of the same formation or class, with the uniform structure and regularity of their uninterrupted stratification, forces the observer's attention to the limits which separate the great and principal classes; on the tracing of which, he finds so much order and regularity, that the bare collection of the *facts* partake somewhat of the delusion of theory.

The prominent feature of the eastern side of the continent of North America, is an extended range of mountains, running nearly north-east and south-west from the St. Lawrence to the Mississippi, the most elevated parts as well as the greatest mass of which consists of *primitive* as far south as the Hudson river, decreasing in height and breadth as it traverses the state of New Jersey. The primitive occupies but a small part of the lower country, where it passes through the states of Pennsylvania and Maryland, where the highest part of the range of mountains to the west consists of transition, with some intervening vallies of secondary. In Virginia, the primitive increases in breadth, and proportionally in height, occupying the greatest mass, as well as the most elevated points of the range of mountains in the states of North Carolina and Georgia, where it takes a more westerly direction.

Though this primitive formation contains all

the variety of primitive rocks found in the mountains of Europe, yet neither their relative situation in the order of succession, or their relative heights in the range of mountains, correspond with what has been observed in Europe. The order of succession from the clay state to the granite, as well as the gradual diminishing height of the strata, from the granite through the gneiss, mica slate, hornblende rocks, down to the clay slate, is so often inverted and mixed, as to render the arrangement of any regular series impracticable.

No secondary limestone has been found on the south-east side of the primitive, nor any series of other secondary rocks, except some partial beds of the old red sandstone formation, which partly cover its lower edge; in this, it seems to resemble some of the European chains, such as the Carpathian, Bohemian, Saxon, Tyrolian and Alpine or Swiss mountains; all of which, though covered with very extensive secondary limestone formations on their north and west flanks, have little secondary limestone on their southern and eastern sides.

The old red sandstone above mentioned, covers partially the lower levels of the primitive, from twelve miles south of Connecticut river to near the Rappahannock, a range of nearly four hundred miles; and though often interrupted, yet retains through the whole distance that uniform feature of resemblance so remarkable in the other formations of this continent. The same nature of sandstone strata is observable, running in nearly the same direction, partially

covered with wacke and greenstone-trap, and containing the same metallic substances. The above uniformity is equally observable in the great alluvial formation which covers the south-east edge of the primitive, from Long island to the gulf of Mexico, consisting of sand, gravel, &c. with marsh and sea mud or clay, containing both vegetable and animal remains, found from thirty to forty feet below the surface.

Along the north-west edge of the primitive, commences the *transition* formation, occupying, after the primitive, some of the highest mountains in the range, and appears to be both higher and wider to the west in the states of Pennsylvania, Maryland, and part of Virginia, where the primitive is least extended, and lowest in height. It contains all the varieties of rocks found in the same formation in Europe, as the mountains in the Crimea, &c. and resembles in this the chain of the Carpathian, Bohemian and Saxon mountains, which have all a very considerable transition formation, succeeding the secondary limestone on their northern sides. Anthracite has been found in different places of this formation, and has not yet been discovered in any of the other formations in North America.

The necessity of such a class or division of rocks as the *transition*, has been doubted by some, nor is it now generally used in the south of Europe; but such rocks are found, and in very considerable quantities, in almost every country that has been examined. There are only two classes, the primitive or secondary, in

which they can be placed. They are excluded from the primitive, by containing pebbles, evidently rounded by attrition when in an insulated state, and by the remains of organic substances being found, though rarely, in them; and yet many of the variety of transition rocks, such as the grey wacke slate, and quartzose aggregates, are hardly distinguishable from primitive slate and quartz when fresh; it is only in a state of decomposition, that the grain of the transition rocks appears, and facilitates the discrimination.

If they are placed with the secondary, they would form another division in the class, already rather confusedly divided; as their hardness, the glossy, slaty, and almost chrystalline structure of the cement of a great proportion of the transition aggregates, would exclude them from any division, as yet defined, of the other secondary rocks. Besides the objections arising out of their individual structure, the nature of their stratification removes them still further from the secondary, and makes them approach still nearer to the primitive. They are found regularly stratified, generally dipping at an angle above twenty and not exceeding forty-five degrees from the horizon; whereas, the secondary rocks are either horizontal or undulating with the inequalities of the surface. A bed of grey wacke, or grey wacke slate and transition limestone, runs south-west from the Potomac to near the Yadkin river, a distance of two hundred miles, from one to five miles in breadth, having the primitive formation on each side,

dipping the same as the primitive, though at a less angle, the strata running in the same direction; and from its relative situation, dip, and stratification, bearing no characters of the secondary, not having been yet found alternating with secondary rocks, it cannot be classed with them, without destroying all order and introducing confusion. To class it with the primitive, would be making the primitive include not only aggregates composed of pieces of different kinds of rocks rounded by attrition, but also limestone with a dull fracture, coloured by organic or other combustible matter, which it loses by being burnt. It would perhaps add to the precision of the classification, if this class was augmented by placing some of the porphyritic and other rocks in it, which are more of an earthy than chrystalline fracture, but which at present are considered as primitive.

It might have been as well if, when giving names to the different classes of rocks, all reference to the relative period of their origin or formation had been avoided; and in place of *primitive* and *secondary*, some other names had been adopted, taken from the most prominent feature or general property of the class of rocks intended to be designated, such as perhaps chrystalline in place of primitive—deposition or horizontal in place of secondary, &c.; but as those old names are in general use, and consecrated by time and long habit, it is more than probable that the present state of our knowledge does not authorise us to change them. The adoption of new names, on account of some

new property discovered in the substance is the cause of much complication and inconvenience already; and if adopted as a precedent in future, will create a confused accumulation of terms calculated to retard the progress of the science. When we change the names given to defined substances, by those who went before us, what right have we to suppose, that posterity will respect our own nomenclature?

On the north-west side of the transition formation, along the whole range of mountains, lays the great *secondary* formation, which, for the extent of the surface it covers and the uniformity of its deposition, is equal in magnitude and importance, if not superior, to any yet known: there is no doubt of its extending to the borders of the great lakes to the north, and some hundred miles beyond the Mississippi to the west. We have indeed every reason to believe, from what is already known, that the limits of this great basin to the west, is not far distant from the foot of the Stony mountains; and to the north, that it reaches beyond Lake Superior, giving an area extending from east to west from Fort Ann, near Lake Champlain, to near the foot of the Stony mountains, of about fifteen hundred miles, and from south to north from the Natchez to the upper side of the great lakes, about twelve hundred miles.

This extensive basin is filled with most of the species of rocks, attending the secondary formation elsewhere, nor is their continuity interrupted on the east side of the Mississippi by the interposition of any other formation except

the alluvial deposits on the banks of the large rivers. The foundation of most of the level countries is generally limestone, and the hills or ridges in some places consist of sandstone: a kind of dark coloured slaty clay, containing vegetable impressions, with a little mixture of carbon, frequently alternates with all the strata of this formation, the whole of which is nearly horizontal. The highest mountains are on the external borders of the basin, gradually diminishing in height towards its centre.

Two divisions of the secondary formation common in Europe have not yet been discovered in this—the chalk formation, and what Werner calls the newest floetz-trap formation. The limestone generally found in this basin is of a bluish colour, running through all the shades to a dingy black, having an even, rather earthy fracture, and sometimes a schistose structure. The flints found in the secondary limestone in America, are generally black, resembling the Lydian stone, and in all kind of irregular forms and branches intimately mixed with the limestone. The limestone, which often follows the chalk formation in countries where chalk has been found, is generally of a white, running into a drab or light-brown colour, a smooth, compact, conchoidal, almost resembling the flinty fracture; having in some parts of the stratum rounded nodules of flint, interspersed apparently without order; the flints in some places light coloured, in others dark; and some of the nodules whitish on the outer edge, and blackish towards the centre.

A very extensive and regular formation of the above mentioned kind of limestone, succeeds the chalk in Europe, and covers the transition formation on the north side of the mountains of the Crimea; holds the same relative situation along the north side of the transition on the Carpathian mountains; continuing through Silesia and Bavaria along the Bohemian mountains to Ratisbon; from thence up the Danube, to Schaffhausen on the Rhine; and follows the north-west side of the Jura, across the Rhone to the Mediterranean: the limestone during this long course, is similar, both in colour and structure; and in some places on the banks of the Danube, is in a schistose form. It is this kind of limestone wherewith they make the plates which afford such exact impressions of writings and designs at Munich; its compact, homogenous structure, without any grain, renders it capable of receiving almost a metallic polish.

The absence of the newest floetz-trap formation (which partially and irregularly covers all other formations, thereby breaking the continuity of the other strata) with the effect of the violent convulsions and earthquakes, so frequent in the vicinity of this disputed formation, may be one cause why the prosecution of geological researches is so much more easy in North America than in Europe. A second cause producing much more universal and extensive effects, may perhaps be found in the difference of the number and magnitude of the accidents and changes that have been effected in the stratifications of the different classes of rocks

on the European continent, since their original formation; by the effects of water, during the immensity of time, partially washing away the superincumbent strata, most liable to decomposition, and leaving the more hard and durable parts of the same stratification in their original positions; or by the long and continual action of rivers wearing deep beds, and exposing to view the subordinate strata, giving to the whole the present appearance of a confused and interrupted stratifications, though it might have been uniform and regular in its original state. Rivers likewise, by undermining, throw immense masses out of their places, and create a disorder and confusion, not easily unravelled.

A third cause of the facility of geological observations on this continent, may arise from the whole continent east of the Mississippi following the arrangement of our great chain of mountains. This chain commences at the St. Lawrence river, and appears to be a spur from the great mass of primitive, which occupies all the northern parts of the continent, runs a southwesterly course to the borders of Florida, is covered by the alluvial, and bounded by the sea on the east side; on the west side it is covered with a considerable transition formation, which is followed by a still more extensive secondary formation, all of which run in a regular line of continuity. Europe, on the contrary, is formed of five or six chains of mountains, all following different laws of stratification, and frequently interrupting each other; which increases the

difficulty of arranging them in groups, and augments the apparent confusion.

The rivers in North America have not generally cut so deep into the different strata, either in the mountains, or during their course through the level country, as materially to derange the stratification; nor do we find those immense and inaccessible precipices, which renders the prosecution of geological researches almost impossible. Broken, detached masses of one formation, covering the tops of mountains, with their sides or foundation composed of different classes of rocks, seldom occurs; and where any irregularity or apparent confusion takes place, the vicinity generally admits of a sufficient examination of the surrounding strata, so as to account for the accident without affecting the general arrangement.

The stratification of the great chains of mountains in Europe is so cut up and deranged by the action of water, wearing deep vallies, surrounded by inaccessible precipices, that at every step some unaccountable difficulty occurs; the stratification is irregular and contradictory, the constant alternation of different formations baffles all the research which the nature of the place will permit of: if persevering industry, by accurate and minute investigation, should reduce to some order one part of the chain, another part of the chain of mountains, changed by different series of accidents, cannot be reduced to order by the same rules; and the observer may perhaps find, that he has not been acqui-

ring the knowledge of the natural structure and arrangement of the original stratification, but only an imperfect idea of some accidental changes. It is probable in such cases, that it would be better to begin with taking general and extensive views of the whole chain, endeavouring to find out the key to the original order of stratification, which would render it more easy to account for the accidents which, when examined separately, appeared to be irreconcileable exceptions.

The difference between the ranges of mountains in Europe and North America, appears to be much greater, as respects the accidental and subsequent changes, than in the original order and arrangement of their stratification, in the relative situation whereof they frequently agree. On the edge of the secondary, not far distant from the transition, have been found the most productive salt springs, yet discovered in North America, running nearly north-east from Pigeon's river in the state of Tennessee, to Lake Onondaga; the salt works at Abingdon, and many other salt springs, though not wrought, occur; and in the same direction of the stratification, gypsum has been discovered. This situation of salt and gypsum, corresponds with the situation of the salt mines at Cracovia in Poland, which, with some others in the same country, are found on the edge of the secondary, almost touching the great transition formation, which covers the north side of the Carpathian mountains.

The country round the Baltic, bounded by a line running easterly to the Hartz, through Silesia, along the Carpathian mountains to the Crimea, and north by St. Petersburgh, including Denmark, part of Russia, Prussia, Finland, Sweden and Norway, is similar to the east side of the river Mississippi in North America, inasmuch, as it contains little or none of the basalt or newest floetz-trap formation; and very few warm springs, in proportion to the surface, have been yet found in either of the countries above mentioned; though on the south side of that line in Hungary and Bohemia, the floetz-trap formation and hot springs are frequent; and in crossing the stony mountains on the west side of North America, between the sources of the Missouri and Columbia river, two very hot springs were found by Captain Lewis: the same mountains likewise contain rocks of the newest floetz-trap formation.

The shells and other remains of organized matter, have not yet been examined with that accuracy of discrimination necessary to form just conclusions. Those found on the south-east side of the primitive are almost exclusively contained in the alluvial, in which considerable banks of shells, mostly bivalves, run parallel to the coast, imbedded frequently in a soft clay or mud resembling much that in which the living animal is now found on the sea shore, which makes the supposition probable, that they are of the same species. The shells found north-west of the primitive range, in the great secon-

dary formation, are in great abundance, and consist of various species of Terebratulæ, Encrinites, Madripores, Caryophillites, Ammonites, Retipores, Nummulites, &c. most of which being washed out of the banks by the agitation of the water, are to be found in high preservation on the south side of Lake Erie.

CHAPTER II.

Observations on the Geology of the United States of America, in Explanation of the geological Map.

NECESSITY dictates the adoption of some system, so far as respects the classification and arrangement of names. The Wernerian seems to be the most suitable, first, because it is the most perfect and extensive in its general outlines—and secondly, the nature and relative situation of the minerals in the United States, whilst they are certainly the most extensive of any field yet examined, may perhaps be found the most correct elucidation of the general accuracy of that theory, so far as respects the relative position of the different series of rocks.

Without entering into any investigation of the origin, or first formation of the various substances, the following nomenclature will be used.

CLASS I.—Primitive Rocks.

SIENA BROWN.

1. Granite,
2. Gneiss,
3. Mica Slate,
4. Clay Slate,
5. Primitive Limestone,

6. Primitive Trap,
7. Serpentine,
8. Porphyry,
9. Sienite,
10. Topaz-rock,
11. Quartz-rock,
12. Primitive Flinty-slate,
13. Primitive Gypsum,
14. White-stone.

CLASS II.—Transition Rocks.

CARMINE.

1. Transition Limestone,
2. Transition Trap,
3. Grey Wacke,
4. Transition Flinty-slate,
5. Transition Gypsum.

CLASS III.—Flœtz or Secondary Rocks.

LIGHT BLUE.

1. (*dark blue*) Old Red Sandstone, or 1st Sandstone Formation,
2. First or Oldest Flœtz-limestone,
3. First or Oldest Flœtz-gypsum,
4. 2d or Variegated Sandstone,
5. 2d Flœtz-gypsum,
6. 2d Flœtz-limestone,
7. 3d Flœtz-sandstone,

8. Rock-salt Formation,
9. Chalk Formation,
10. Flœtz-trap Formation,
11. Independent Coal Formation,
12. Newest Flœtz-trap Formation.

CLASS IV.—Alluvial Rocks.

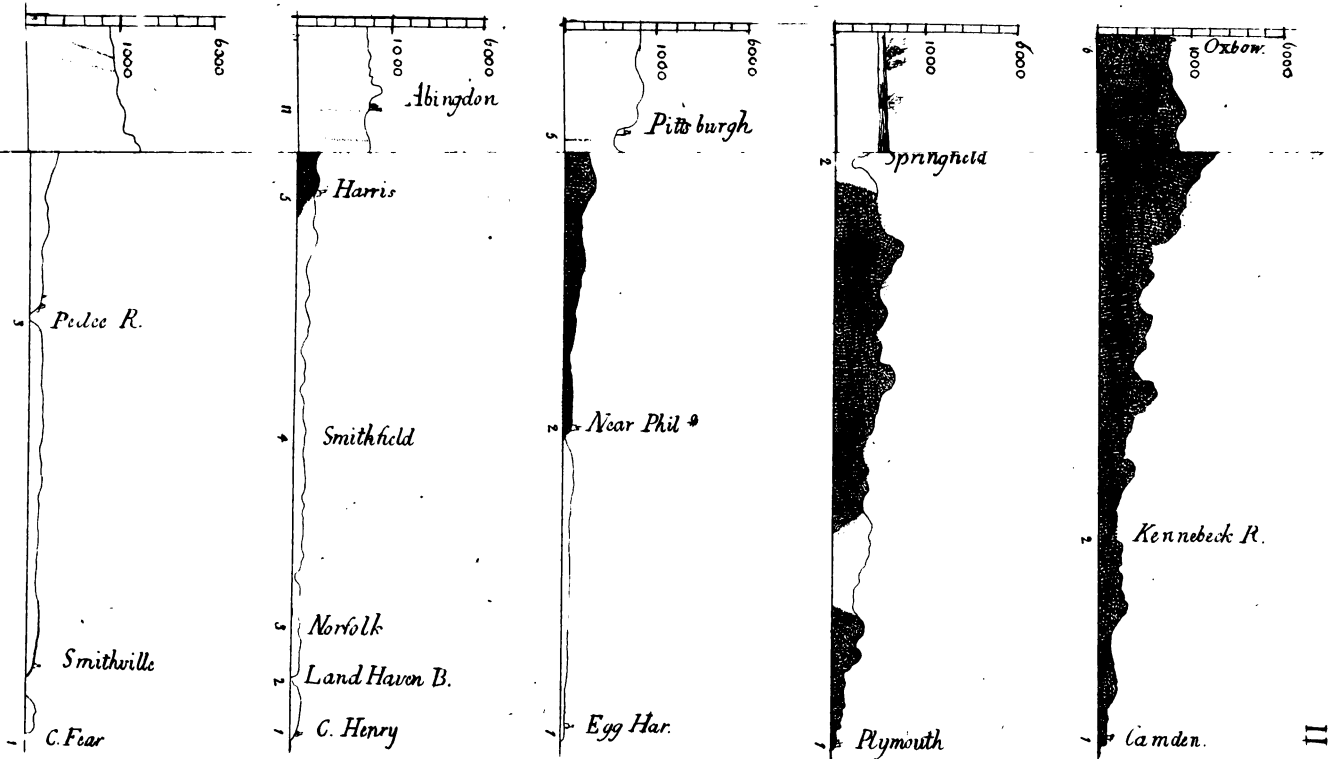
YELLOW.

1. Peat,
2. Sand and Gravel,
3. Loam,
4. Bog Iron-ore,
5. Nagel-fluh,
6. Calc-tuff,
7. Calc-sinter.

GREEN.

All the rock salt and gypsum hitherto found in the United States, has been traced westward of this line.

To the east of Hudson's river, the primitive class prevails, both in the mountains and in the low lands, decreasing gradually as it proceeds south; it is bounded on the side of the ocean by the vast tracts of alluvial formation which skirt the great granite ridge, while it serves as a foundation to that immense superstructure of transition and secondary rocks forming the great chain of mountains that occupy the interior of the continent to the westward.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Smithville
C. Fear
Abingdon
Harris
Smithfield
Norfolk
Land Haven B.
C. Henry
Pittsburgh
Near Phil.
Egg Har.
Springfield
Plymouth
Oxbow.
Kennebeck R.
Camden.

8. Rock-salt Formation,
9. Chalk Formation,
10. Flœtz-trap Formation,
11. Independent Coal Formation,
12. Newest Flœtz-trap Formation.

CLASS IV.—Alluvial Rocks.

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2. Sand and Gravel,
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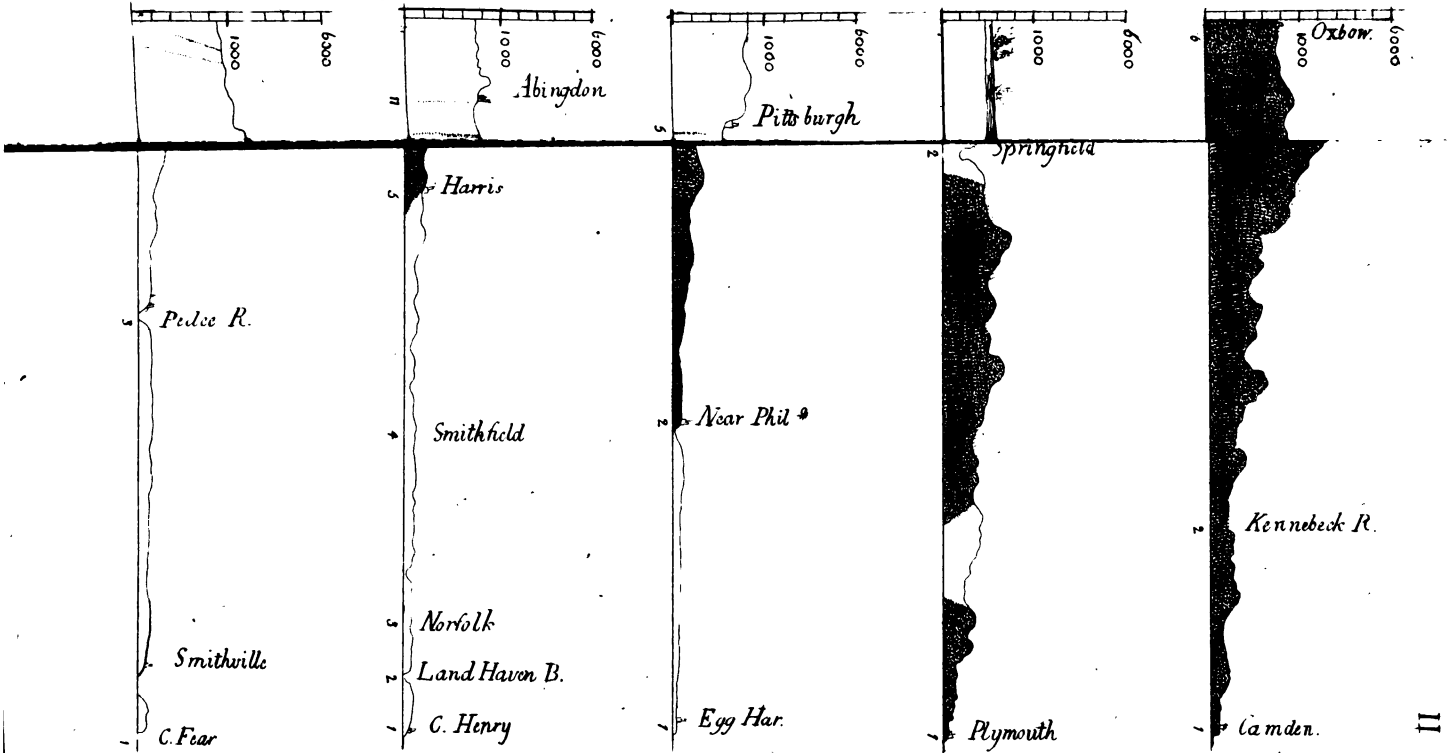
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Land Haven B.
C. Henry
C. Fear
Egg Har.
Plymouth
Camden.
II

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9. Chalk Formation,
10. Flœtz-trap Formation,
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CLASS IV.—Alluvial Rocks.

YELLOW.

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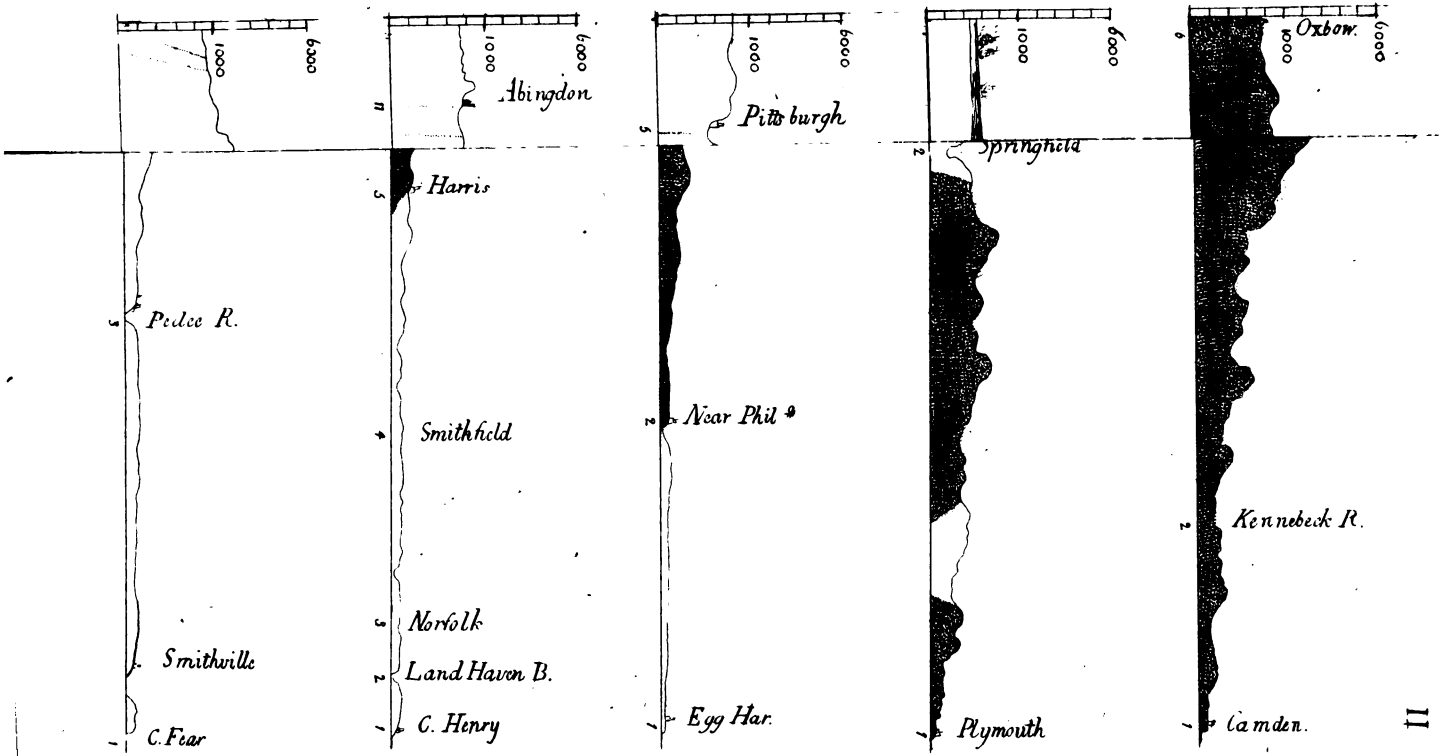
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Egg Har.
Springfield
Plymouth
Oxbow.
Kennebeck R.
Camden.
II

The primitive, to the eastward of Hudson's river, constitutes the highest mountains, while the little transition and secondary that is found, occupy the low grounds. To the south of the Delaware, the primitive is the first rock after the alluvial formation of the ocean—the lowest step of the stair which gradually rises through the different formations to the top of the Alleghany.

To the eastward of the state of New York, the stratification runs nearly north and south, and generally dips to the east, looking up to the White Hills, the most elevated ground. In New York state, and to the southward and westward, the stratification runs nearly north-east and south-west, and still dips to the east. All the rivers east of the Delaware run nearly north and south, following the stratification, while the southern rivers incline to the south-east and north-west directions.

Throughout the greatest part of the eastern and northern states, the sea washes the foot of the primitive rock; the deposition of that extensive alluvial formation commences at Long island, increasing in breadth to the south, forming a great part of both the Carolinas and Georgia, and almost the whole of the two Floridas and lower Louisiana. The coincidence of the gulf stream, with all its attendant eddies, depositions, &c. rolling along this whole extent, from the gulf of Mexico to Nantucket, may create speculative ideas on the origin of this vast alluvial formation, while the constant supply of caloric brought by that sweeping current from

the tropics, may perhaps account for the sudden and great change in the temperature of the climate within the reach of the Atlantic.

The great distance occupied by the same or similar substances in the direction of the stratification, must strike the observer; as in the primitive rocks, the beds of primitive limestone and dolomite, containing in some places chrystallized feldspar and tremolite, which are found alternating with gneiss, for ten miles between Dover, state of New York, and Kent, state of Connecticut, appear forty miles north at Stockbridge, Connecticut, and eighty miles south, between Singsing and Kingsbridge, New York; where, after crossing the Hudson river, and dipping under the trap and sandstone formation in New Jersey, they most probably reappear in the marble quarries distant from twelve to fourteen miles north-west of Philadelphia—a range of nearly three hundred miles.

There is a bed of magnetic iron ore, from eight to twelve feet thick, wrought in Franconia, near the White Hills, New Hampshire; a similar bed in the direction of the stratification six miles north-east of Philipstown on the Hudson river, and still following the direction of the stratification, the same ore occupies a bed nearly of the same thickness at Ringwood, Mount Pleasant and Suckusanny in New Jersey, losing itself as it approaches the end of the primitive ridge near Blackwater; a range of nearly three hundred miles.

Instances of the same, occur in the transition and secondary rocks; as the Blue Ridge, from

the Hudson river to the Dan river, consists of rocks of much the same nature and included in the same formation.

That no volcanic productions have yet been found east of the Mississippi, is not the least of the many prominent features of distinction between the geology of this country and that of Europe; and may perhaps be the reason why the Wernerian system so nearly accords with the general structure and stratification of *this* continent.

It is scarcely necessary to observe, that the country must be considered of the nature of the first rock that is found in place, even should that rock be covered with thirty or forty feet of sand or gravel, on the banks of rivers or in valleys; for example, the city of Philadelphia stands on primitive rock, though at the Centre Square, thirty or forty feet of sand and gravel must be penetrated, before the gneiss rock, which ascertains the formation, is found.

ALLUVIAL CLASS.

At the east end of Long island the alluvial begins, occupying almost the whole of that island. Its north-western boundary is marked by a line passing near Amboy, Trenton, Philadelphia, Baltimore, Washington, Fredericksburg, Richmond, and Petersburg in Virginia, a little to the westward of Halifax, Smithfield, Aversboro', and Parkersford on Pedee river, in North Carolina, west of Cambden, near Columbia, Augusta on

the Savannah river, Rocky Landing on the Oconee river, Fort Hawkins on the Ockmulgee river, Hawkinstown on Flint river, and running west a little southerly across the Chatahouchee, Alabama and Tombigbee rivers, it joins the great alluvial basin below the Natchez.

The ocean marks the eastern and southern limits of this extensive alluvial formation; above the level of which it rises considerably in the southern states, and falls to near the level of the sea, as it approaches the north.

Tide water in all the rivers from the Mississippi to the Roanoke, ends at a distance from thirty to one hundred and twenty miles of the western limits of the alluvial: from the Roanoke to the Delaware, the tide penetrates through the alluvial, and is only stopped by the primitive ridge. The Hudson is the only river in the United States, where the tide passes through the alluvial, primitive transition, and into the secondary; in all the northern and eastern rivers the tide runs a small distance into the primitive formation: here, as in the northern coasts of Europe, little or no alluvial is found on the primitive coast.

Through the whole of this alluvial formation considerable deposits of shells are found; also a bank of shell limestone beginning in North Carolina, parallel to, and within the distance of from twenty to thirty miles of the edge of the primitive, through South Carolina, Georgia, and part of the Mississippi territory. In some places this bank is soft, with a large proportion of clay, in others hard, with a sufficiency of the calca-

reous matter to be burnt for lime: large fields of the same formation are found near cape Florida, and extending some distance along the coast of the bay of Mexico; in some situations the calcareous matter of the shells has been washed away, and a deposit of siliceous flint, in which they were imbedded, is left; forming a porous flinty rock, which is used with advantage for millstones.

In the alluvial of the New Jersey, about ten to twenty feet under the surface, there is a kind of greenish blue marl, which they use as manure, in which they find shells, as the Ammonite, Belemnite, Ovulite, Cama, Ostrea, Terebratula, &c. Most of these shells, are similar to those found in the limestone and grey wacke of the transition, and equally resemble those found in such abundance in the secondary horizontal limestone and sandstone; from which it would follow, that the different classes of rocks on the continent cannot be distinguished by their shells, though the different strata of the same class may be discovered and known by the arrangement of the shells found in them.

Considerable deposits of bog iron-ore occupy the lower situations, and many of the more elevated and dividing ridges between the rivers are crowned with a sandstone and puddingstone, the cement of which is bog iron-ore.

Quantities of ochre, from bright yellow to dark brown, are found in abundance in this formation, in flat horizontal beds, alternating with other earths in some places, in others in kidney-

form masses, from the size of an egg to that of a man's head; in form, resembling much the flint found frequently in chalk formations.

So great an extent of alluvial, formed at periods of time so distant, though at present and from all the examinations yet bestowed, it appears to be the same formation, may at some future period and by future observations, be found to contain rocks similar to those of the secondary class; for instance, the whole or part of the greenish blue marl with shells, found in Jersey, both the Carolinas, and Georgia, may in process of time become solid and compact, and would then under the denomination of shell limestone, enter into the secondary, as well as many of the sandstones and puddings; for a bank of sand or gravel, united by a filtration of water, which deposes either clay or limestone as a cement, cannot be different from a like formation in the secondary. Even the early depositions of lime by the evaporation of lime water, such as at Tivoli, near Rome, cannot in hand specimens be distinguished from compact limestone of the secondary class. It is probable, that those immense masses of trees, accumulated on the banks of the Mississippi and other large rivers, may be covered by alluvial beds of sand and clay, which in process of time will consolidate into the coal measures of slate and sandstone, while the mass of wood will decompose into beds of coal, and become, under the denomination of the coal formation, secondary rocks.

PRIMITIVE CLASS.

The south-east limits of the great primitive formation are covered by the north-west boundary of the alluvial formation from near the Alabama river, in the Mississippi territory, to Long island, with two small exceptions; the first near Augusta on the Savannah river, and near Cambden in South Carolina, where a stratum of transition clay slate, (shist argileux) intervenes; and from Trenton to Amboy, where the oldest red sandstone formation covers the primitive along the edge of the alluvial. From Rhode Island along the coast by cape Cod, to the bay of Penobscot, the eastern edge of the primitive is bounded by the ocean.

The north-western boundary of this extensive range, is marked by a line running fifteen to twenty miles east of Lake Champlain, twelve miles east of Middlebury, state of Vermont, west of Bennington, twelve to fifteen miles east of Hudson, along the westward of Stockbridge, twelve miles south-east of Poughkeepsie, skirting the high lands; it crosses the Hudson river, at Philipstown, by Sparta, about ten or fifteen miles east of Easton on the Delaware, and terminates in a point a few miles north of Bethlehem, recovering fifteen miles west of Trenton; on the south side of the river it passes about the same distance west of Philadelphia, eight miles east of Downingstown, ten miles east of York by Petersburg, crosses the Susquehannah, twenty-two miles west of Washington, and joins the

Blue Ridge, along the top of which is the dividing line between the primitive and transition to Magotty Gap, from thence to four miles east of the lead mines at Austinville, and following a south-western direction, by the Stony and Iron mountains, six miles south-east of the warm springs in Buncomb county, in North Carolina, to the eastward of Hightown on the Cousee river; and a little to the westward of the Talapoosee river, it meets the alluvial near to the Alabama, which runs into the bay of Mexico.

Besides this range, there is a great mass of primitive on the west side of Lake Champlain, having that lake and Lake George for a boundary on the east, joining the primitive in Canada to the north and north-west, and following a line from the Thousand islands in St. Lawrence, running nearly parallel to the Mohawk, until it meets Lake George as a south-west limit. This primitive runs across the Mohawk at the Little Falls, and near to Johnstown on the Mohawk, where it is covered by limestone; it occupies all the mountainous country, between Lake Champlain, the St. Lawrence, and Lake Ontario.

In general, the strata of this primitive rock runs from a north and south to a north-east and south-west direction, and dips generally to the south-east at an angle of more than 45 degrees from the horizon; the highest elevation is towards the north-western limits, which gradually descends to the south-east, where it is covered by the alluvial; and the greatest mass as well as the highest mountains, are found to-

wards the northern and southern extremities of the north-western boundaries.

The outline of the mountains of this formation, generally consists of circular, waving, detached masses, with rounded flat tops, as the White Hills to the north; or conically waving in small pyramidical tops, as the peaks of Otter, and the ranges of hills to the south. Has the climate any agency in the forms of the summits of the northern and southern mountains? Their height does not appear to exceed six thousand feet above the level of the sea, except perhaps the White Hills; it is even probable that those mountains are not much higher.

Within the limits prescribed to this primitive formation there is found the following exception, viz. Covering part of this primitive there is a transition formation, which occupies all Rhode Island (except a small part south of Newport) and runs from Rhode Island to Boston from ten to fifteen miles broad, and by the rounded transition pebbles, which cover part of the primitive, as well as the small patches left at Pembroke township, and ten miles south-west of Newburyport, on the new turnpike, it is probable that at some former period this transition has covered the primitive considerably east of Boston, perhaps as far as cape Cod. There is also a range of secondary, extending with some intervals, from the Connecticut to the Rappahannock rivers, in width generally from fifteen to twenty-five miles; bounded on the north-east, at New Haven, by the sea, where it ends to recommence on the south side of Hud-

son river. From Elizabethtown to Trenton it touches the alluvial: from a little above Morrisville, on the Delaware, to Norristown, Maytown on the Susquehannah, passing three miles west of York, Hanover, and one mile west of Frederickstown: it is bounded, or rather appears to cover a tongue of transition, which occupies a progressively diminishing width, as far south as the Yadkin river, at Pelot's Mount.

This secondary formation is intercepted after it passes Frederickstown, but begins again between Monocasy and Seneca creeks, the north-eastern boundaries crossing the Potomac by the west of Cartersville, touches the primitive near the Rappahannock, where it finishes. On the north-west side, it is bounded by the primitive, from some distance to the westward of Hartford, passing near Woodbury, and recommencing south of the Hudson, passing by Morristown and Germantown, &c. to the Delaware; after which it continues along the transition, by the east side of Reading, Grub's mines, Middletown, Fairfield, to near the Potomac, and recommencing at Noland's ferry, runs along the edge of the transition to the westward of Leesburg, Haymarket, and the vicinity of the Rappahannock.

All this secondary, appears to belong to the oldest red sandstone formation;* though in

* The oldest red sandstone family or formation in most places in Europe where I have seen it, such as on the south side of the Vosges, the south of the Alps, Tyrolian and Bohemian mountains, the south side of the Pyrenees, &c. consists of compact red sandstone, schistose red sandstone, and

some places about Leesburg, Reading, &c. the red sandstone only serves as cement to a pudding formed of transition limestone, and other transition pebbles, with some quartz pebbles, large beds of greenstone trap and wacke of different kinds, which covers in many places this sandstone formation, and forms the small hills, or long ridges, that occur so frequently in it.

The stratification in most places runs from an east and west to a north-east and south-west course, and dips generally to the north-west, at an angle most frequently under twenty-five degrees from the horizon, covering both the primitive and transition formation, at every place where their junction could be examined; and in some places, such as on the east side of the Hudson (where the action of the water had worn away the sandstone) the smooth water-worn primitive, was covered with large rolled masses of greenstone trap, to a considerable distance; the hardness and solidity of which, had most probably survived the destruction of the sandstone formation. May not similar derangements be one of the causes of the broken and unconnected state of this formation?

schistose blackish sandstone, coloured by carbon; a bluish schistose sandstone, running into wacke, compact wacke, schistose wacke, blue compact conchoidal limestone, seldom thicker than from six inches to a foot, small strata of two or three inches thick of jet, a pudding with the red sandstone for cement, greenstone and hornblende trap in ridges, and salt and gypsum. It has thus been found in Europe as above stated. All the members of this family have been found alternating with each other in the United States, except the gypsum; and there appears little reason to doubt but that more accurate research will find this likewise.

Prehnite and Zeolite are found in the trap of this formation; and considerable deposits of magnetic iron ore at Grub's mines, are enveloped, and have their circular layers intersected by greenstone trap; on a ridge of which, this extensive cluster of iron ore seems to be placed.

Grey copper ore has been found in the red sandstone formation, near Hartford and Washington in Connecticut; there are likewise mines in New Jersey, where copper pyrites and native copper have been found. The metallic veins at Perkiomen creek, containing copper, pyrites, blend and galena, are in the same formation, running nearly north and south across the east and west direction of the red sandstone, and a small bed from a half to three inches thick, of brown or red copper ore is interspersed, and follows the circular form of the iron beds at Grub's mines.

Besides this red sandstone formation, there is included within the described limits of the primitive, a bed of transition rocks, running nearly south-west from the Delaware to the Yadkin river, dipping generally to the south-east, twenty-five or more degrees from the horizon; its width is from two to fifteen miles, and it runs from the west of Morrisville to the east of Norristown, passes Lancaster, York, Hanover, Frederickstown, Bull-run mountain, Milton, foot of Pig river, Marlinsville, and finishes near Mount Pilot, on the Yadkin river. Between the Delaware and Rappahannock it is partially covered by the red sandstone formation, and is in the form of a long wedge, the thick end

touching the Delaware and the sharp end terminating at the Yadkin river.

This range consists of beds of blue, grey, red, and white small grained transition limestone, alternating with beds of grey wacke and grey wacke slate, quartzy granular rocks, and a great variety of transition rocks. Much of this limestone is intimately mixed with grey wacke slate, others containing so great a quantity of small grained sand as to resemble the dolomite, and in many places considerable beds of fine grained white marble, fit for the statuary, occur.

Limespar runs in veins and detached masses through the whole of this limestone formation; and both it and the grey wacke slate contain quantities of the cubic pyrites. Galena has likewise been found near Lancaster, and many veins of the sulphat of barytes traverse this formation, which runs about twenty-five to thirty miles south-east, and nearly parallel to the great transition formation.

A similar formation about fifteen miles long, and two to three miles wide, occurs on the north fork of Catawba river, running along Linnville and John's mountain near to the Blue Ridge; and a bed of transition rock, commencing on Greenpond mountain, New Jersey, runs through Suckusanny plains, increasing in width as the primitive range decreases, joining the great transition formation between Easton and Reading.

On the west side of this partial transition formation, from the Potomac to the Catawba, between it and the great western transition

range, a series of primitive rocks intervenes, something different from the common primitive, having the structure of gneiss, with little mica, the scales detached and not contiguous, or much feldspar, rather granular than chrystallized; mica slate, with small quantities of scaly mica; clay slate, rather soft and without lustre, the whole having a dull earthy fracture and gritty texture, partaking of transition and primitive, but not properly belonging to either. This rock is always found on the edge of the primitive, before you come upon the transition, but no where in such quantities as in this range. There is great variety in the appearance of this rock, an imitation of almost every species of the common primitive rocks, but differing from them by having a dull earthy fracture, gritty texture, and little or no chrystallization.*

About ten or twelve miles west of Richmond, Virginia, there is an independent coal formation, twenty to twenty-five miles long, and about ten miles wide; it would not be far distant from

* This class of rocks differs from the primitive, in having a less brilliant and chrystalline fracture, but corresponds with it in the direction and almost vertical position of the stratification: it differs from the transition in not containing any of those aggregates, the component parts whereof have been evidently rounded by attrition, and in the circumstance of affording no remains of organic matter, though many of the species of schist, taken separately, have a great resemblance to some of the schistose rocks, included in the transition formation. In conformity to the Wernerian nomenclature, they are here classed with the primitive, as not coming properly under any description of rocks described as transition in that system.

the range of the red sandstone formation had it continued so far south; it is situated in an oblong basin, having the whitish freestone, slaty clay, &c. with vegetable impressions, as well as most of the other attendants of that formation. This basin lays upon and is surrounded by primitive rocks. It is more than probable, that within the limits of so large a mass of primitive, other partial formations of secondary rocks may be found.

Granite in large masses forms but a small part of this formation, and is found indifferently on the tops of mountains and in the plains; it is both large and small grained, is mixed occasionally with hornblende and talc, and contains, as in Europe, rounded masses of a rock consisting of hornblende and feldspar in small grains, disseminated through it; it generally divides vertically into rhomboids, and, except in some very small grained, there is no appearance of stratification, when found in low situations, as in the interior of South Carolina and Georgia. It is frequently so far decomposed as to have lost the adhesion of its particles, to the depth of thirty or forty feet below the surface; each chrystal is in its place, and looks like solid granite, while you may take it up in handfuls like sand and gravel.

Gneiss extends perhaps over a half of this formation, and includes in a great many places beds from three to three hundred feet thick, of a very large grained granite, which run in the same direction, and dip as the gneiss does; it is in those beds generally where the emerald,

phosphat of lime, tourmaline, garnet, cymophane, octahedral iron ore, graphic granite, &c. &c. are found. These beds are mixed, and alternate occasionally in the same gneiss, with the primitive limestone, the beds of hornblende and hornblende slate, serpentine, magnetic iron ore, and feldspar rocks. In some places this gneiss contains so much mica, as to run into mica slate; in others, large nodules of quartz or feldspar; in others, hornblende takes the place of the mica; in short, I scarcely know any of the primitive rocks that may not occasionally be found included in the gneiss formation.

It is therefore probable that geology must rest, more upon relative positions, than upon the constituent parts of rocks. For instance; the hornblende rocks which cover the red sandstone, are in many places so chrystalline, as scarcely to be distinguished in hand specimens from some of the hornblende rocks which alternate with the gneiss; it is the same with much of those small grained rocks of trappose forms, found in the primitive, compared with the transition trap or hornblende rocks found in the transition; though the latter alternate with transition slate, or what is called roofing-slate, in which the remains of organic matter have been found.

The rounded globules of feldspar and hornblende found in the great masses of granite of the Alps, in Cornwall, and in this country, could not be distinguished, in hand specimens, from the sienite of Werner, though the one is placed in the Wernerian system as the oldest, and the

other among the newest, of the primitive rocks, all which proves the difficulty of establishing a line in the gradations of nature to place our artificial boundaries on; and indicates the necessity of first ascertaining the limits of the great divisions, before we attempt the specific and more minute, which would seem to require more accurate and extensive observations, than have as yet been made.

There is a compact, rather dull fractured hornblende rock, generally found on the edge of the primitive, before meeting with the transition, which is in many places mixed with epidote, both compact and chrystalline; as on the south side of Rhode Island, and along the Blue Ridge, in Virginia, &c. &c. This rock resembles the rock found in the harbour of Penzance in Cornwall, and not unlike the rock of the Lizard in England. From its appearing here always on the edge of the primitive, it is probably one of the last members of that class.

No gypsum has yet been found in the primitive of this country; nor do I think it will be ascertained to have been in place, when alternating with the primitive in Europe, having examined the gypsum near Mont St. Gothard, Mont Cenis, Coll de Tende, &c. &c. In the Alps I found it always in transition, though in one or two places that transition had slid down from the top of a neighbouring mountain into a valley of primitive rocks.

Great varieties of mineral substances are found in the primitive formation, such as garnets in the granite and mica slate, from the

size of a pin's head to the head of a child, staurotide, andalusite, epidote in vast varieties and abundance, tremolite, all the varities of magnesian rocks, emerald, touching graphic granite, and disseminated in the granite of a large extent of country, adularia, tourmaline, hornblende, sulphat of barytes, arragonites, &c. &c.

From the number already found in proportion to the little research that has yet been employed, there is every reason to suppose, that in so great an extent of chrystalline formation, almost every mineral discovered in similar situations on the ancient continent of Europe will be found on this.

Metallic substances in the primitive, are generally extensive, like the formation itself. Iron pyrites runs through vast fields, principally of gneiss and mica slate; magnetic iron ore, in powerful beds from ten to twelve feet thick, generally in a hornblende rock, occupies the highest elevations, as in Franconia, the Highlands of New York, the Jerseys, Yellow and Iron mountains in the west of North Carolina. A black brown bed of hematitic iron ore in Connecticut and New York states. Chrystals of octahedral iron ore, (some of which have polarity) disseminated in granites, as at Brunswick, district of Maine, and in many varieties of the magnesian genus; black lead in beds, from six to twelve feet wide, traversing the states of New York, Jersey, Virginia, Carolina, &c.; native and grey copper ore, near Stanardsville, and Nicholson's Gap, Virginia, disseminated in a hornblende and epidote rock, bordering on the tran-

sition; molybdena at Brunswick (Maine), Chester (Pennsylvania), Virginia, North Carolina, &c.; arsenical pyrites in large quantities in the district of Maine; red oxyd of zinc and magnetic iron ore in a powerful bed on the edge of the primitive, near Sparta in New Jersey, having a large grained marble, with nigrin or silico-calcareous titanium imbedded in it on one side, and hornblende rock on the other. This bed contains likewise large quantities of blende. Detached pieces of gold have been found in the beds of some small streams in Cabarro county, North Carolina, and other places, apparently in a quartz rock. Manganese has been found in New York, North Carolina, &c. &c. Near the confines of the red sandstone and primitive formation, a white ore of cobalt has been wrought above Middletown on the Connecticut river, and found also, as is said, near Morristown in New Jersey.

The general nature of metallic repositories in this formation, appears to be in beds, disseminated, or in laying masses; when in beds (as the magnetic iron ore and black lead) or disseminated (as the iron pyrites, octahedral iron ore, molybdena, &c. &c.) they occur at intervals through the whole range of the formation. Veins to any great extent have not yet been discovered in this formation.

TRANSITION CLASS.

This extensive field of transition rocks is limited on the south-east side from a little to

the eastward of Lake Champlain to near the river Alabama, by the north-west boundary prescribed to the primitive rocks. On the north-west side it touches the south-east edge of the great secondary formation, in a line that passes considerably to the westward of the ridge which divides the eastern and western waters in Georgia, North Carolina, and part of Virginia, and runs near it in the northern part of that state and in the states of Pennsylvania and New Jersey.

This line of demarcation runs between the Alabama and Tombigbee river, to the westward of the north fork of the Holstein, till it joins the Alleghany mountains, near the sulphur spring along that dividing ridge to Bedford county in Pennsylvania, and from thence north-east to Fort Ann, near Lake Champlain, and follows the east side of that lake to Canada: the separation of the transition and secondary is not so regularly and distinctly traced as in the other formation; many large vallies are formed of horizontal secondary limestone, full of shells, while the ridges on each side consist of transition rocks. The two formations interlock and are mixed in many places, so as to require much time and attention to reduce them to the regular and proper limits. It is however probable, that to the north-west of the line here described, little or no transition will be found, although to the south-east of it, partial formations of secondary may occur.

The transition formation is generally broadest where the primitive is narrowest, and vice

versa; and runs from twenty to one hundred miles broad: the stratification runs from a north and south to a north-east and south-west direction, dipping generally to the north-west, at an angle in most places under forty-five degrees from the horizon. On the edge of the primitive it deviates in some places from this general rule, and dips for a short distance to the south-east: the most elevated ground is on the confines of North Carolina and Georgia, along the south-east limits to Magotty Gap, descending towards the north-west until it meets the secondary; from Magotty Gap, north-easterly, the highest ground is on the north-west side, sloping gradually towards the primitive, which ranges along its south-eastern boundary.

The outline of the mountains of this formation is almost a straight line, with few interruptions, bounding long parallel ridges of nearly the same height, declining gently towards the side, where the stratification dips from the horizon, and more precipitous on the opposite side, where the edge of the stratum breaks out to the day.

This formation is composed of the following rocks; viz. a small grained transition limestone, of all the shades of colour from a white to a dark blue, and in some places intimately mixed with strata of grey wacke slate; limespar in veins and disseminated; in many places an intermixture of small grained particles, so as to put on the appearance of a sandstone, with excess of lime cement. This occurs in beds from fifty to five thousand feet in width, alternating

with grey wacke and grey wacke slate. Near the borders of the primitive is found a siliceous aggregate, having particles of a light blue colour, from the size of a pin's head to an egg, disseminated in some places in a cement of a slaty texture, and in others in a quartzose cement; a fine sandstone cemented with quartz in large masses, often of a slaty structure, with small detached scales of mica intervening; a rock not far from the borders of the primitive, partaking both of the porphyry and the grey wacke, having both feldspar chrystals and rounded pebbles in it, with a cement of a kind of dull chlorite slate in excess; another, though rarer, with pebbles and feldspar chyrstals in a compact petrosiliceous cement, and a great variety of other rocks, which, from their composition and situation, cannot be classed but with the transition.

The limestone, grey wacke, and grey wacke slate, generally occupy the vallies, and the quartzy aggregates the ridges; amongst which is what is called the country burr stone or mill stone gritt, which must not be confounded with another rock, likewise denominated mill stone gritt, which is a small grained granite, with much quartz, found in the primitive formation. There are many and extensive caves in the limestone of this formation, where the bones of various animals are found.

Beds of coalblende, or anthracite, accompanied by alum slate and black chalk, have been discovered in this formation, on Rhode Island, the Lehigh and Susquehannah rivers; and a

large body of alum slate on Jackson's river, Virginia; many powerful veins of the sulphat of barytes cross it in different places; granular, as that near Fincastle, or slaty, as that in Buncomb county, North Carolina.

Iron and lead have as yet been the principal metals found in this formation; the lead in the form of galena, in clusters, or what the Germans call Stockwerk, as at the lead mines on New river, Wyeth county, Virginia; the iron disseminated in pyrites, hematitic and magnetic iron; or in beds; and considerable quantities of the sparry iron ore in beds, and disseminated in the limestone.

This class of rocks, occupying the space between the primitive and secondary, is perhaps the first that ought to be studied and the limits fixed; as a knowledge once acquired of what rocks are transition, there can be no difficulty in distinguishing the secondary at one end and the primitive touching the other.

As nature in her imperceptible gradations from one species of rock to another, has not left any marked or distinct limits, on which to place the artificial boundaries of the different classes, it is not easy to fix with certainty the kind of rocks, at which the one class ought to begin, and the other finish; and it is probable that a long series of exact observations will be necessary to determine with accuracy that line of separation.

It is probable, that between the secondary and transition class, the *horizontal stratification* of the secondary will constitute the strongest

and best defined line of separation; every stratum of rocks that is horizontal, or nearly so in its original situation, will be secondary; and those which are found near it, not chrystalline or primitive, having a regular dip or declination from the horizon, will naturally fall into the transition class. It is under this idea that the dark blue colour on the map has been used for the oldest red sandstone, while the light blue has been the mark of the secondary, because I have generally found the oldest red sandstone dipping or declining from the horizon at a regular angle though small; and at the same time having few organic remains; which agrees with the general characters of the transition: whilst in relative position on the sides of many of the range of mountains it assumes the place of the transition.

The line between the primitive and transition may perhaps be marked by the presence or absence of organic remains—or of aggregates of rounded particles, the result of former decomposition—in part, by the more or less chrystalline texture—and its approach towards deposition.

SECONDARY CLASS.

The south-east limit of this extensive formation is bounded by the irregular border of the transition, from between the Alabama and Tombigbee rivers to Fort Ann near Lake Champlain. On the north-west side it follows the shores of the great lakes, and loses itself in the

alluvial of the great basin of the Mississippi; occupying a surface from two hundred to five hundred miles in breadth, and extending probably on the west side of the Mississippi to the foot of the Stony mountains.

This horizontal limestone and slate, skirt Lake Champlain about Ticonderoga and Crown Point, and for some considerable distance down the east side of the lake; seldom extending above half a mile from the edge of the water; containing some shells and flints, as on Lake Erie, and appears to be the same formation as on Lake Erie. Its greatest elevation is on the south-east boundary, from which it falls down almost imperceptibly to the north-west, and mingles with the alluvial of the Mississippi, having an outline of mountains, straight and regular. A boundary of long and parallel ranges of a gradually diminishing height as they approach to the north-west limits; a stratification almost perfectly horizontal, waving with the inequalities of the surface, distinguishes this from the two preceding formations.

Immense beds of secondary limestone, of all the shades from a light blue to a black, intercepted in some places by extensive tracts of sandstone and other secondary aggregates, appears to constitute the foundation of this formation, on which reposes the great and valuable coal formation, which extends from the head waters of the Ohio in Pennsylvania, with some interruption, all the way to the waters of the Tombigbee, accompanied by the usual attendants, slaty clay and freestone, with vegeta-

ble impressions, &c.; but in no instance that I have seen or heard of, covered by, or alternating with any rock, resembling basalt; or indeed any of those called the newest floetz trap formation.

The limestone of this formation contains irregular pieces in nodules and bands, of a kind of black flint (like what is called chert in England) scattered in all forms and directions, often resembling in colour the limestone, in which case it is with difficulty they can be distinguished; they abound on the banks of Lake Erie, on the banks of St. Lawrence, where it runs from Lake Erie, and generally through the whole stratification of limestone.

Along the south-east boundaries not far from the transition, a rock salt and gypsum formation has been found. On the north fork of Holstein, not far from Abingdon, Virginia, and on the same line south-west from that, in Greene county and Pigeon river, state of Tennessee, it is said quantities of gypsum have been discovered; from which, and the quantities of salt licks and salt springs found in the same range, so far north as Lake Oneida, there is some probability that this formation is upon the same great scale that almost all the other formations have been found on this continent; at least rational analogy supports the supposition; and we may hope one day to find an abundance of those two most useful substances, which are generally found mixed or near each other in all countries that have hitherto been carefully examined.

At Lewistown, ten miles below the falls of Niagara, the old red sandstone appears from under the limestone and other strata over which the falls roll; the same makes its appearance near the Salines in the Genesee country, which would give some probability to the conjecture, that the old red sandstone is the foundation of all this horizontal formation, and may perhaps be attached to some series of rocks laying on the primitive, on the north side of the lake.

Metallic substances, hitherto found in this formation, are iron pyrites, disseminated both in the coal and limestone; iron ores, consisting principally of brown, sparry and clay iron stone in beds; galena, but whether in beds or veins is not ascertained. The large deposits of galena at St. Louis on the Mississippi, have been described as detached pieces, found covered by the alluvial of the rivers, and of course, not in place. All the large specimens I have seen were rolled masses, which rather confirms the opinion, that they were not found in their original situation.

On the Great Kanhawa, near the mouth of Elk river, there is a large mass of black (I suppose vegetable) earth, so soft as to be penetrated by a pole ten or twelve feet deep; out of the hole so made, frequently issues a stream of hydrogen gas, which will burn for some time; and in the vicinity of this place there are constant streams of that gas, which, it is said, when once lighted will burn for several weeks. Query, if a careful examination of this place would not throw some light on the formation of coal and other

combustible substances found in such abundance in this formation?

Large detached masses of granite are found laying on this formation from Harmony to Erie, and from thence by the Genesee country to Fort Ann; though in many places no granite of this kind is found in place nearer than two hundred miles at the falls of the Mohawk, or perhaps on the north side of the lakes.

From near Kingston on Lake Ontario to some distance below Quebec, the country is principally primitive, and from all the information I could collect, that great mass of continent laying to the north of the 46th degree of latitude for a considerable distance to the west consists mostly of the same formation: from which it is probable, that on this continent, as well as in Europe and Asia, the northern regions are principally occupied by the primitive formation.

The foregoing observations are the results of many former excursions in the United States, and the knowledge lately acquired, by crossing the dividing line of the principal formations in twenty-five or thirty different places, from the Hudson to Flint river; as well as from intelligent men, whose situation and experience made the nature of the place, near which they lived, familiar to them; nor has the information that could be acquired from specimens where the locality was accurately marked, or the remarks of judicious travellers, been neglected.

Notwithstanding the various sources of information, much of the accuracy of the outlines of separation between the formations must depend

on rational analogy; for instance, between Magotty and Rock-fish Gaps, a distance of upwards of sixty miles, I found in six different places that were examined that the summit of the Blue Ridge divided the primitive and the transition formation. I concluded of course, that in places where I had not examined (or which from their nature could not be examined) that the Blue Ridge, from Magotty to Rock-fish Gap, was the boundary of the two formations.

In adopting the nomenclature of Werner, I do not mean to enter into the origin or first formation of the different substances, nor into the nature and properties of the agents that may have subsequently modified and changed the appearance and form of those substances. I am equally ignorant of the relative periods of time, in which those modifications and changes may have taken place. These speculations are beyond my range, and pass the limits of my inquiries. All that I mean by a *formation*, is, a mass of substances (whether adhesive, as rocks, or separated as sand and gravel) uniform and similar in their structure and relative position, occupying extensive ranges with few or no interruptions of the rocks belonging to another series, class, or formation; and when such partial mixture apparently takes place, a careful examination will seldom fail to explain the phenomenon, without injuring the general principle, or making it a serious exception to the rule.

In the account of the metals and minerals, it is not intended to give a list of the number,

extent, and riches of the metallic and mineral repositories; the nature of the ore or mineral, with a description of its relative position in regard to the surrounding substances, is the principal object of geology, which cannot be understood by microscopic investigations or the minute analysis of insulated rocks and detached masses; it would be like the portrait painter dwelling on the accidental pimple of a fine face; the geologist must endeavour to note the great and permanent outlines of nature, and get acquainted with her general laws, rather than study her accidental deviations, or magnify the number and extent of the supposed exceptions which must frequently cease to be such when accurately examined.

CHAPTER III.

Hints on the Decomposition of Rocks, with an Inquiry into the probable Effects they may produce on the Nature and Fertility of Soils.

Rocks in their natural hard and compact state afford little or no nourishment to vegetables; it is only in their state of decomposition and dissolution, that they become useful or necessary to the growth of plants.

The greatest part of the substances which constitute most soils, proceeding immediately from the decomposition of the rocks surrounding or laying under them, it follows of course that those soils must be materially affected by the nature and quality of those rocks: first, by the peculiar mode of their decomposition and dissolution into earth or liquids, and secondly by the nature and qualities of those earths and liquids in the formation of soils, and as food for vegetables. We shall now consider their mode of decomposition.

1st.—The mode of decomposition by dissolution in water, as limestone and gypsum.

2dly.—Rocks, which though not soluble in water, yet contain something which facilitates the solution of earths, as alkalies, &c. such as feldspar, miça, volcanic rocks, &c.

3dly.—Rocks which decompose into small, minute particles, such as argillaceous slate, hornblende, talc, and serpentine.

4thly.—Rocks which decompose only by trituration, such as flints, quartz, &c. and those which contain siliceous matter as a component part of their aggregates, such as granite, gneiss, &c.

It has been generally supposed that vegetables cannot absorb any earth in a solid state, and that solution was necessary to render any substance fit for the food of plants. Those earths, therefore, that remain in a solid state, and are indissoluble by the common fluids, most probably act only as a medium through which the plant may receive the proper proportion of the two great causes of vegetable growth, heat and moisture; two fluids, positively necessary for the support of vegetable as well as animal life, neither of which could exist without a certain quantity of heat and moisture. This is proved by the total sterility of the polar regions and the tops of high mountains from the deficiency of heat, and of the deserts of Arabia, Africa, &c. from the absence of moisture.

Earths, as a medium through which the plants may be supplied with their necessary quantity of fluids, may act in various ways; first, as a soil easily reduced by tillage into a moveable mass offering the least possible resistance to the roots of plants, when in search of their food, and at the same time facilitating the circulation of such fluids as are indispensible to their growth, as absorbents of heat and moisture. Earths as well as rocks, differ greatly in their capability of receiving more or less of

those necessary fluids, because they vary in their property of retaining one or both of them, for a longer or shorter time.

Earths as well as rocks may injure materially the fertility of the soil, by allowing one or both those fluids to filter through them, thereby depriving the plant of its necessary portion. In the same manner, rocks as a sub-stratum may be useful or beneficial to the plants which grow on the surface, by their greater or less capacity of retaining the necessary fluids, as Fabroni has shewn.

It may be proper to mention here, that the effect either of rocks in their compact state as rocks, or in their decomposed state as earths, forming the soil, is the only subject of these hints or observations; and that all artificial or accidental additions of animal or vegetable matter in a decomposed state, must be considered as exceptions of the general results. Whether these decompositions of vegetable or animal matter have been scattered over the surface by the annual fall of the leaves of the forest, and decay of animal or vegetable matter—or whether the floods of rivers have covered the lower ground with their fertilizing vegetable mud—or whether the industry and ingenuity of man has strewed it over the soil as manure—the results of all such additions must be considered as foreign to the present subject, excepting inasmuch as the properties of the original soil may conduce to retain and prolong the advantages of this adventitious cause of fertility.

When a farmer clears the land of the United

States under the trees, he finds a stratum of black vegetable mould, more or less thick in proportion to the original properties of the soil, the time that the trees have been dropping their manure upon it, and the declivity which obstructs or facilitates its washing away; for this mould is lighter than water, and runs off rapidly from the sides of hills, and seldom or ever lays long on the steep descents of mountains.

While this bed of vegetable mould remains, the labour of the farmer is rewarded by rich and abundant crops; for when he sows and reaps from such a soil, four or five years before he exhausts it, he not only expends as many years' natural productions, but he consumes as many hundred or perhaps thousand years' accumulation of natural manure, which would require a very long time for the common operations of production and decomposition to replace.

It is therefore the peculiar interest of all farmers in America, to be sparing of this natural manure, and to make it last as long as they can, which may perhaps be best effected by preventing as much as possible its washing away with the rain,* a much greater proportion run-

* The quantum of vegetable mould in a soil has been considered as a criterion of its richness. To ascertain it, a chemist dries perfectly a given quantity and weighs it; after which he exposes it to a red heat, and weighs the residue; the difference between the two weights is considered as the quantity of vegetable matter lost by combustion, and of course the measure in a great degree of its fertility.

Where this vegetable mould is not more than three to four inches thick, perhaps ploughing it in like stable ma-

ning off with the water than is consumed by the production of the vegetables raised on it.

While this vegetable mould is in sufficient quantities on the surface, the lands are more or less fertile, independent of the nature of the earth on which it lays; it is when that coat of manure is gone, and the land worn out by constant cropping,* that the soil shews its fertility, as depending on the nature of the rock of the country, and species of earth or loam, resulting from their decomposition. It is at that time that the difference between a granite and limestone soil appears, and where any one can see the effects, though few ever think of inquiring into the cause; yet it is evident that the washing and decomposition of a granite soil, can only afford sand mixed with a small proportion of sand or clay, from the mode in which the rocks divide in their process of decomposition; and even this small quantity is liable to filter through the interstices left in the aggregates of gravel, by the form of their chrystalline particles.

The limestone, on the contrary, by its easy solution and facility of decomposition, furnishes

nure, by ploughing a little deeper might be one means of keeping it from washing; as this process would cover it with a part of the soil, which from its weight would not be so easily washed away.

* A great deal of the soil east of the Alleghany mountains does not produce now much more than one half it did when first cleared, which is probably one of the causes why the surplus produce of the United States for exportation is not now greater, if so great, as it was twenty years ago, though the quantity of land under culture, as well as the population that tills it, is almost double.

to the exhausted soil, with every rain, a quantity of food, fitted by solution for vegetable absorption, as well as a great quantity of mould divided and triturated into impalpable powder, which forms an excellent pabulum through which the vegetable can receive the other fluids necessary for its growth. Meantime this mould forms a retentive base or soil, which prevents the filtration of the smaller particles, and even retains the water in its pores, so as to give it out by regular evaporation to the surface, when necessary for the increase and support of the plants that may be sown on the land.

Beside the division of rocks into those which dissolve in and easily mix with water, as their mode of decomposing, and those which are insoluble in water, this last species of rocks are divided by their mode of decomposition into chrystalline, and deposition rocks; because when changing from the solid rock into earth or soil, they follow a different process which produces different effects.

First, the chrystalline rocks are composed of an aggregation of chrystals of various substances interwoven and adhering together by the laws of attraction. Such rocks generally begin to decompose by a disunion of the different chrystals, and a destruction of their adhesion; then they fall into a mass of angular particles like a bed of gravel, and form a filter, through which all fluids pass more or less rapidly in proportion to the size of the chrystals; after which, each chrystal, according to its nature, begins its de-

composition by throwing off an exceeding thin pellicle from its surface, and this continues scaling off until it is totally reduced; all those thin scales falling into the banks of angular particles, are generally washed by the water and filter through it; so that the residue consists of a mass of such substances as do not decompose easily but by trituration, and forms a granular bed of sand or gravel according to the size of the particles.

Rocks of deposition, consisting of particles more or less minute, arising from the decomposition of other rocks, when aggregated into a mass and fixed either by a cement or by juxtaposition, are subjected to laws of decomposition different from other rocks; for when the adhesion of their particles is destroyed, they fall immediately into a state of earth more or less pervious to fluids, according to the nature of the particles; which being the result of a former decomposition are minute, and when pressed together by their own weight, form a mass which does not permit the fluids to pass in such quantities as to carry along with them the finest particles, and of course are not subject to wash away by filtration, like the remains of chrystalline rocks, though perhaps more easily carried off by the water from the steep sides of the hills.

All rocks which divide in the trappose form into parallelopipeds, not by chrystallization, but by shrinking or retraction from the loss of heat or moisture, fall into considerable square masses, and decompose by first losing their corners and

approaching the round form, constituting a part of the rounded pebbles found in our fields; which are not rounded by attrition of water or any other cause of movement, but by the general mode of decomposition of homogeneous rocks.

It may perhaps be considered as a general principle that the farther the agents of decomposition can penetrate into rocks, insoluble in water, the greater will be the quantity that they will decompose in a given time; and the quicker that decomposition into minute particles is effected, the smaller will be the quantity washed away by the rains, and of course the necessary thickness of the soil for the production of vegetables will accumulate more rapidly; this must depend on the hardness and compactness of the rock, and all rocks of the slaty or the schistose form must be more easily reduced into soil, than those in a solid mass.

Rocks of easy decomposition into minute particles, accumulate a thickness of soil sufficient to prevent the filtration of any small particles that may be added to it, and form a bottom capable of holding what it obtains; on the contrary, rocks which in the first stage of decomposition fall into granular pieces of an angular form, leaving spaces through which all minute particles (produced by the slow decomposition of hard or chrystalline rocks) can filter along with the water, form no bottom or foundation for the accumulation of soil fit for vegetable production, but remain dry and steril; it is only

on the lower ground of such countries that soil can accumulate.

To the foregoing general principles of the decomposition of rocks, there will be many exceptions when compared with actual results, arising from local observation and experience; and those exceptions will be in proportion to our deficiency in the knowledge of the various modes of working which nature employs, and our ignorance of the variety and nature of the new mixtures and compounds formed by all changes resulting from a natural process.

Great allowance must likewise be made for the action of water; for example, a river rises in a secondary country, and after traversing through limestone and other secondary rocks some hundreds of miles, it flows through a primitive country, carrying with it all the gravel and mud it has collected; it follows of course, that soils, formed of such depositions, though in a primitive country, must partake of the properties and fertility of a secondary soil, as the decomposition of limestone gravel, giving off a coat of decomposed limestone every year, will keep up the soil; on the contrary, rivers running through secondary countries, after having long flowed over primitive, will carry along with them primitive sand and gravel that will partake of the properties of primitive soils, though formed in secondary countries.

After examining some of the effects that would most probably be produced on the soil, by the decomposition of the different classes of rocks, we shall endeavour to apply the princi-

ples to the soils of the United States, in reference to the accompanying map.

The primitive, or chrystalline class, is not favourable to the forming of soil fit for vegetation.

1st. It has no remains either of vegetable or animal matter.

2dly. It is slow to decompose, and easily washed away.

3dly. It is generally situated on higher elevations, owing in some degree to its difficult and slow decomposition.

4thly. There is little or no calcareous earth in the primitive; the strata found occasionally in the gneiss, mica slate, &c. are seldom more than from twenty to one hundred feet in thickness, and do not affect much the surrounding soils.

5thly. The particles of chrystals are so minute and so compactly placed by the laws of affinity, that they absorb little or no moisture.

6thly. For the same reason they are perhaps bad absorbers and still worse retainers of heat; which may be one cause why primitive soils are so cold.

7thly. They have no gypsum in them, and very little of any other rock, soluble in water.

8thly. They have no carbon or any species of coal in their stratification, though coals are often found in the secondary basins they enclose.

The first primitive rock is the granite, which is a granular aggregate of chrystals, decomposing into a gravelly mass: this rock pro-

ceeding slowly through the other stages of decomposition, is liable to run off through the filter, or wash down the declivity.

Gneiss, from its fissile structure and additional quantity of mica, is of easier decomposition, not quite so easily washed, and forms a soil a little more argillaceous.

Mica slate has still more argil in it, and decomposes more rapidly.

Clay slate in general forms a tough strong soil, and retains the little it receives.

The accidental beds of limestone, hornblende, and serpentine, found in the three last mentioned rocks, are so small and partial, as not to affect the general nature of the soil, though their almost perpendicular position brings the edges of all the stratifications of the above mentioned rocks to the surface, and thereby renders a mixture of their component parts almost a certain consequence of their decomposition. This is one advantage the primitive has in common with the transitions, as it is more than probable that such a mixture would form a better soil than the decomposition of any one of the different strata, if isolated by being in a horizontal position; for this would confine the formation of soil to the decomposition of the uppermost stratum.

The hornblende rocks, either compact or slaty, often have small particles of pyrites scattered through them, which hastens decomposition into fine red mould, perhaps the best soil of all the primitive rocks.

Serpentine, as well as the greatest part of

the magnesian genus, though decomposing easily with a stiff clay, is nevertheless unfriendly to vegetation; perhaps from the soil being so strong and adhesive as to prevent the vegetable roots from penetrating; in that case, sand might be a good manure.

Whether it is from the elevation in height, rigour of climate, or from the various other defects before mentioned, it may be safely laid down as a general position, that the primitive is covered with a soil less productive than the other classes of rocks, and serves as a foundation for much of the steril regions of the north, as well as the burning sands of the deserts.

The rivers of this class roll over precipices and rocky beds full of obstructions, scarcely admitting any continued navigation. So, when the primitive touches the ocean, it forms what is called a bold shore with perpendicular precipices, deep water, and harbours free from banks, or any other obstructions from the alluvial class.

Abundance of fine springs of clear good water, more free from all the impurities of foreign substances than in any other of the classes, are found in this class of rocks; which at the same time are generally healthy and favourable to human existence.

Quartz in small chrystalline particles being a constituent part of this class, it is of course from the decomposition and minute trituration of this quartz by the action of currents of water or wind, that we obtain the greatest part of our siliceous sand. Great masses of rocks, in rolling, form an impalpable powder, but do not

form sand. It is this class that may be supposed to furnish the materials for the formation of all the aggregates of the three following classes, except perhaps the limestone, and the remains of vegetable and animal matter.

TRANSITION CLASS.

The greatest part of the rocks of this class decompose into soils favourable to vegetation.

1st. They are composed of particles, previously the result of the decomposition of other rocks; and are more easily and rapidly turned into soil.

2dly. They contain some remains of vegetable and animal matter.

3dly. With a few exceptions of those that are near the primitive, they consist either of limestone, or of rocks that have some quantity of lime in their composition.

4thly. They contain large beds of gypsum.

5thly. Being aggregates of minute rounded particles, they permit the absorption of heat; and not being good conductors, are useful in retaining it.

6thly. They absorb moisture and retain it.

7thly. They are subject, though in a less degree, to one disadvantage attending the primitive, that is, they occupy high and broken countries.

8thly. This class holds considerable masses of anthracite, and other rocks containing carbon.

The sandstone of the transition class, is difficult to decompose, and consisting for the most

part of silex, makes a light gravelly soil; the greatest part of the rolled pebbles in the alluvion of this class, are sandstone.

Two kinds of aggregates are found in this class, one having a base of a greenish slate, with chrystals of feldspar and rolled pebbles, and another consisting of rounded masses of a light blue quartz, in a fibrous cement; both of these are near the primitive, and partake of its qualities, that is, decompose slowly into a sand or gravel.

Grey wacke decomposes likewise into a sand or gravel; but the cement, consisting of clay and lime, forms a considerable part, and makes a tolerable soil.

Grey wacke slate of all kinds, consisting of small rounded particles, imbedded in a considerable quantity of clay mixed with lime, and generally alternating with strata of limestone, from one inch to one hundred feet thick, decomposes into a fine loam, favourable for vegetation.

Limestone, which is found in large and extensive fields in the transition class, is likewise favourable to the formation of a good soil; but is subject to the inconvenience of forming caves, and allowing much of the water which falls on the surface, to filter through, and form little streams under the surface, which deprives the soil of its necessary moisture. This is sometimes prevented by the alternation of the grey wacke slate, which stops the circulation and throws the water out to the surface. Hence it is probable, that the alternation of the grey

wacke slate with the limestone, will form a more productive soil, than when the limestone is in great masses and extensive fields.

This class generally covers the primitive, and is often found on the flanks of steep mountains, of course liable to wash, and leave the rocks bare of soil; but when it is found in low and level situations, it decomposes into a mould easily wrought and favourable to vegetation.

Being in the vicinity of mountainous and broken countries, the rivers run through it rapidly; it is therefore unfavourable to navigation.

The water is tolerable, but not so pure as that of the primitive class, holding often a small quantity of lime or salt in solution; but it is much purer than the limestone water of the secondary class, the limestone of which dissolves in water more easily and in much greater quantities.

This class, placed between the primitive and secondary, partakes of the properties of both. It has the advantage of consisting of rocks formed by the aggregation of particles the result of former decompositions, like the secondary; and resembles a little the primitive in its situation and constant declination from the horizon. This regular dip or declination from the horizon, throws the edges of all the strata on the surface, which gives to the soil formed by their decomposition the benefit of a mixture, which horizontal strata cannot produce; for example, a country composed of transition slate, limestone and sandstone, alternating in strata of from one foot to one hundred feet thick, in a state of de-

composition, forms a soil, which consists of a mixture of the component parts of all the three species of rocks. This will most probably be superior for vegetation to any soil formed entirely of the decomposed particles of any one of the rocks, as would be the case, if they were in a horizontal position; it is therefore probable, that the nature of the soil is more varied, and does not continue for any great distance exactly similar, as is found in the extent of barren sand, found both in the secondary and alluvial, owing perhaps to their horizontal position.

SECONDARY, OR HORIZONTAL CLASS.

This class has many properties favourable to the growth of vegetables.

1st. It is horizontal, or nearly so; forms large level plains; and drops down by plates or embankments, seldom or never precipitous, like the two last classes.

2dly. It consists of aggregations of particles, the result of former decompositions; soft and easily reduced into mould.

3dly. It contains the remains of vegetable and animal matter in abundance.

4thly. It has much limestone strata, and rocks containing a considerable proportion of lime.

5thly. It contains large beds of gypsum and salt.

6thly. Coals are principally found in this class, as well as many compound rocks containing carbon.

7thly. Being aggregates of minute rounded particles, not so compact as the transition, they have more interstices for the reception and retention of heat.

8thly. For the same reason, they absorb and retain moisture.

The oldest red sandstone is one of the principal members of this class, and partakes a little of the properties of the transition, in having a much greater proportion of cement, consisting of fine clay mixed with the oxyd of iron, and forms a good soil; the other sandstones, united by the infiltration of water with a small proportion of cement, decompose into sand, and form a dry barren soil.

Limestone, alternating with a slaty clay mixed with carbon, forms an excellent loam and good soil. Limestone by itself, in large fields, is likewise favourable to a good soil, when it does not run into caves and under-ground drainings, which deprives the surface of its necessary moisture.

Chalk decomposes into good soil, when level; but is apt to wash, and leave only a thin soil, when in hills or steep declivities.

Sand and salt are perhaps the least favourable to vegetation of all the substances of this class; and when joined together in a warm climate, form barren deserts. Where the salt water runs under the sand, and is stopped by some stratum from going further, it has a constant tendency to mount to the surface, either by capillary or some other attraction. Arrived at the surface, the water is evaporated, and the salt

left on the sand, frequently preventing all vegetation, and at best producing coarse and bad grass.

Gypsum has as yet only been found in the United States in this class, though in time it is possible that great quantities will be found, as in Europe, in the transition.

The properties of gypsum as a manure, are too well known to the farmers of the United States, by an extensive and profitable application, to require any elucidation. Why so small a quantity, as a bushel to the acre, should produce such astonishing fertility, has been a matter of controversy. Some are of opinion that it acts as a stimulant, others that it attracts the moisture of the atmosphere, &c.; but I should be rather inclined to think, that it owes its fertilizing power to its solubility in water, the same quantity of water dissolving more of this rock than any other.

Vegetables cannot absorb any substance, unless it be in a state of complete solution; but the quantity of earthy matter found in vegetables is exceedingly small; it would therefore follow, that should that small quantity of earthy matter be presented to the mouths of the vegetable absorbents in a complete state of solution, they would take up as much as was necessary for the future developement of the plant, and would only require afterwards the free access of the fluids of heat and moisture, which contribute so much to vegetable growth and production. Now this quantity of earthy substances, is furnished by the small quantity of

the powdered gypsum thrown over the plant, which dissolving by the first rain or even dew, carries what is necessary to the mouths of the absorbents, and in this manner supplies the plant with all the earthy particles necessary for its future growth.

There are two negative proofs in favour of this supposition; first, that gypsum when burnt, loses the greatest part of its fertilizing powers, and at the same time is deprived of its property of easy solution; whereas limestone, when burnt, is of easy solution in water, and forms good manure, but in its natural state is not so easily dissolved in water, nor is it nearly so good for vegetable production; in both cases their utility as a manure appears in the direct ratio of their solubility in water.

The same theory is confirmed by the limestone land, being more favourable to the growth of vegetables, than soils produced by the decomposition of siliceous clay rocks; and perhaps for the same reason, that is, the solubility of limestone, which, though a better manure when burned, because more soluble in water than in its natural state, yet even in its state of limestone rock, it is more soluble in water than those rocks composed of siliceous or argillaceous earths.

It may perhaps be found that artificial composts, used as manure, derive part of their fertilizing qualities from the salt and alkalies they contain, having the properties of facilitating the dissolution of the different earths, and reducing them to a state of liquidity, capable of being

absorbed by the vegetable as food, and of course accelerating its future growth.

The doctrine of stimulants may perhaps be applied to vegetable as well as animal life; but even in animals their common food is the principal stimulant they take, and it is probable that stimulant without nourishment is only applied in a diseased state, and when often applied to a healthy subject, will create a state of disease that will require a continuance of their irritating effects.

The supposition, that the gypsum acts as the healthy stimulant of the food of animals, both as a stimulant and nourishment to the vegetable, is perhaps carrying the analogy of animal and vegetable life as far as our present knowledge of the nature of both will admit.

As all substances used as manure for land, are bulky, and cannot bear the expense of land carriage any distance, the advantage of an easy river navigation is inappreciable to agricultural pursuits; this advantage is one of the most valuable attached to the secondary class of rocks, which from their horizontal position and small elevation, permit the rivers to run slowly over deep and unobstructed beds nearly from their sources to the ocean; so that all the small ramifications of the inferior streams can transport limestone, coal, gypsum, &c. to the door of every farm house, and carry away his surplus produce to market on easy terms.

This horizontal position, by allowing only one of the strata to appear, is the cause of large tracts of country being covered with the same

kind of soil, the result of the decomposition of the same kind of rocks. Nothing but lowering or raising the level to the full thickness of the strata can change it; which is unfortunate where a sandstone is at the surface, decomposing into vast regions of sand; which, if it had been mixed with the strata of slaty clay, that might perhaps be found under it, would form good soil. This class of rocks falls or rises by plateaus, with large fields of table land, in general having a soil very different from each other, because they are formed from the decomposition of rocks of a very different nature.

Springs of water are of very different qualities in this class of rocks, depending on the nature of the strata through which they filter. Those which pass through sandstone, have the best chance of being purest; slaty clay, and all those argillaceous rocks that accompany coals, are often saturated with the neutral salts of copperas or alum, the result of the decomposition of pyrites which they often contain, or of common salt. The limestone of this class is so easily dissolved in water, that the greatest part of the water that traverses the limestone of it, is fully impregnated with lime, and deranges materially the bowels of strangers for the first day or two that they drink it. This is so frequent a quality attending the limestone in a horizontal position, or secondary limestone, that it may perhaps be considered as one of the characteristic properties, by which to distinguish it from the limestone of the primitive or transition class.

ALLUVIAL CLASS.

This class consists of every thing that is washed from all the other classes and deposited in beds, either from the waves of the sea, or of lakes, the currents of rivers, of winds, &c.

It possesses the advantage of being nearly level, and not subject to wash.

When deposed by the action of rapid running rivers, it is generally sand and gravel and poor soil; but where slow running rivers overflow their banks, they for the most part leave a rich vegetable mould, making a fertile soil.

The sea most usually agitated, leaves sand or gravel on its shores, which is likewise the case with the great lakes; this seldom forms a good soil.

In this class we find the greatest quantity of marshy soil, rich in vegetable production, but difficult to drain, on account of its low and unhealthy situation.

Marle is one the best depositions for making good soil, and is generally found in alluvial situations by the sediment of rivers that have run through limestone countries. The gravel deposited by rivers, which run through a limestone country, decomposes into good soil, and may be called a limestone soil; but the depositions of sand and gravel, from rivers running through primitive countries, partake of the qualities of primitive rocks, and form but a dry, light soil.

Extensive plains of sand are often found in the alluvial formed by the sea; these frequent-

ly change place by the wind, and form a series of small hills, covering in many places large tracts of low country, which it renders barren and unfit for production.

Inland navigation in this class is extensive and commodious, the rivers running slowly and smoothly over deep beds, renders them navigable to near their sources. The navigation from the Caspian sea to the Baltic, by the Wolga and the Neva, carries boats upwards of one hundred tons burthen, with only one canal of about a mile long to join the two rivers, there being only four feet difference of level between them; all which long navigation, is through alluvial for the greatest part of the distance. That junction of the waters of the Black sea and the Baltic, by river navigation across Poland, is likewise through an alluvial country. The internal navigation of alluvial countries is generally good; but where the alluvial forms a sea coast, the harbours and bays are difficult and dangerous, obstructed with sand banks and shoals.

From the nature of the aggregation of alluvial materials, they generally consist of a considerable mixture of different substances, yet from its horizontality, it sometimes contains extensive tracts, covered with soil of the same or similar depositions, being the result of the same causes, such as the sand thrown up by the action of the waves of the sea, &c.

The alluvial of small vallies, situated in broken and mountainous countries, has a much better chance of being rich and fertile than of large vallies in level countries; because in proportion to

the extent of the surface, they receive the washings of a much greater extent of soil, than those large vallies in level countries can possibly receive from surfaces whose horizontal position prevents their washing. It is from this cause, that the few small vallies, found in primitive countries, are so rich, and form so great a contrast with the soil of the mountains.

TRAP CLASS.

This class, though exceedingly limited in extent, generally lays over all the others, and occupies the tops of hills.

1st. It is of difficult decomposition, being hard and adhesive, but falling easily into trappose pieces.

2d. It is capable of absorbing and retaining moisture, resembling in a small degree lava, being full of very small interstices.

3d. It is equally capable of absorbing and retaining heat.

4th. Being a partial and scattered class, it is mixed, and covers all the rocks of the other classes, and of course, in the formation of soil, partakes of their quality.

The basalt of this class decomposes slowly, but forms a good soil, where it does not wash. The wacke and porphyries decompose into strong clay soil, capable of retaining the manure put into it, and in low situations form a tolerable soil.

Tuffa, and other loose aggregates of this

class, partake of the nature of volcanic rocks when decomposed, and form excellent soils.

VOLCANIC CLASS.

This is a partial, irregular, and variegated class, and has many properties highly favourable to vegetation in its decomposed state.

1st. From its origin it generally occupies elevated situations.

2d. It contains from one-twentieth to one-tenth of alkali, which favours its decomposition, and perhaps its dissolution.

3d. Though hard, and often chrystalline, yet it is in some places full of pores, and in general has innumerable small interstices, which both absorb and retain moisture.

4th. For the above reason it both absorbs and retains heat.

Lava, when compact and approaching the vitrified slate, is exceedingly slow of decomposition; but when decomposed in low places, it forms a rich soil; the fuller it is of pores, the more easily it decomposes, and of course makes the soil deeper and more productive.

All kinds of volcanic ashes, with all kinds of tuffas, form fine rich mould, and in a short time equal in thickness the bed of ashes or tuffa; the fertility of such a soil is inexhaustible.

From the foregoing investigation it may perhaps be concluded, as a general result, that the oftener rocks have undergone decomposition

and trituration into minute particles, the more fit they are to produce and support vegetables; and the more frequently they have been moved from one place to another, by the agents of decomposition, the more plain and level is the situation they are left in: after every change, this may be traced from the primitive through the transition and secondary to the alluvial; the surface of the decomposition, after such change, becoming less steep and precipitous, approaching nearer and nearer to a level, fit for the reception and retention of all matter, both fluid and solid, capable of assisting vegetable growth.*

To the above general result, the trap and volcanic, or what some would call the old and new volcanic formations, are exceptions as to situation; being thrown from an opening in the surface, the matter ejected must accumulate round the mouth of the crater and its vicinity; and the oftener it is remitted and ejected, the higher will most probably be the mountains it forms, and of course less fit for the production of soil and situation favourable to the growth of plants; this is one of the striking contrasts between the Neptunian operations and the vol-

* In aid of nature's operations to reduce the particles of earth to a state more fit for vegetable production, comes the industry and ingenuity of man, by digging, ploughing, harrowing, and manuring; they much accelerate the progress of ameliorating the earth's surface, and thus accomplish in a few years of labour judiciously applied, what nature would require many centuries to effect by operations of her general laws.

The perfection of all the arts, therefore, only prepares the means of a more rapid and certain progress towards perfection, and who can fix the limits where it shall stop?

canic, that are daily going on under our eyes; rains and rivers wash down the mountains into the plains, while fire heaps up the plains into high and precipitous mountains.

Considering that the action of fire is but partial, and the action of water constant and general, the prospect into futurity is consoling and cheerful; that the earth is every day moulding down into a form more capable of producing and increasing vegetable matter, the food of animals, and consequently progressing towards a state of amelioration and accumulation of those materials, of which the moderate and rational enjoyment constitutes great part of our comfort and happiness. On the surface of such an extensive and perpetual progression, let us hope that mankind will not, nay cannot, remain stationary.

On looking back to the probable past, without going so far as to interfere with any of the present general laws of nature, it may occur, that before all this alluvial, secondary or transition had been rolled about, pounded up and mixed by the rains and rivers, united with the various operations of vegetable and animal production, the state of this earth most probably was different, when the first lichen began to accelerate the progress of decomposition on the surface of the first rock.

CHAPTER IV.

The probable Effects, which the Decomposition of the various Classes of Rocks may have on the Nature and Fertility of the Soils of the different States of North America, in reference to the accompanying geological Map.

It may be necessary again to say, that these observations are only adapted to the earthy part of soils, and are not applicable to soils where the operations of nature in covering the surface with the decomposition of vegetable and animal matter, or the industry of man in putting manure, has mixed the soil with a considerable quantity of vegetable mould. Such soils are productive so long as the vegetable mould remains. The earth formed by the decomposition of the rocks, or the rocks in their original state, are only accessory to the production of this mould, in proportion to their quality of producing a more or less quantity of vegetables, and their property of retaining the vegetable mould a greater or less period of time.

Over the extended surfaces which one class of rocks covers, some considerable exceptions to general rules must be expected; such as remains, or partial patches of a different class of rocks, overlaying the general stratification, and producing effects on the soil, conformable to the properties of the class they belong to. An example of this on a large scale is to be found in the Redlands, which crosses Virginia in the

direction of the Green mountains, and penetrates considerably into North Carolina. These lands, though resting in many places upon a primitive formation, differ from the generality of primitive soils; they contain little or no sand, fall into impalpable powder, and I believe hold a small portion of lime; if there should be an extensive mass of hornblende rocks intimately mixed with pyrites, the decomposition of such a mixture might perhaps produce a similar soil, but such a circumstance rarely happens. It is therefore more probable, that this extensive bed is the remains of a transition formation, part of which still runs near it and under it, from the Delaware to the Yadkin. Although at present this formation is by no means so broad and extensive as the red soil, yet it might formerly have been competent to produce an alluvial of that extent. The red soil, and this narrow bed of transition, running in the same direction and always together, though the red soil covers a much greater surface at present, renders the supposition the most probable that it is the decomposition of a bed of transition limestone and grey wacke, that formerly covered a much greater surface than it may now do; or it may be perhaps a continuation of the red sandstone, which begins at Connecticut river, and finishes near the Rappahannock, with some few interruptions; or it may be a bed of alluvial, transported from a great distance by the movement of waters that have long since ceased to act. As the transition strata accompany it through its whole course, the most rational conjecture

is, that it is the decomposition of a transition bed formerly more extensive than at present. In this manner many partial beds of a different class form patches over a general formation, producing soils that to a superficial observer might become a great exception to the general principle, though when accurately examined, only tend to confirm and support the general rule.

By reference to the accompanying geological map it will be seen, that the four New England states consist mostly of the primitive class of rocks, except in two places; the one from the boundary line between Vermont and Massachusetts, on the Connecticut river, south of Middletown, and from thence to New Haven, in breadth from fifteen to twenty-five miles, composed of the oldest red sandstone formation.

The second exception is the greatest part of Rhode Island, and from thence to Boston, where about fifteen miles broad of the primitive is covered by the transition class or formation, and from the remains of a few patches of transition to the east and north-east of Boston, with the beds of transition pebbles found on the primitive. In that direction it is more than probable that the transition has extended, at some former period, much farther to the north-east.

To the west the New England states, including the district of Maine, are bounded by a range of high and rugged mountains, where the vallies are very narrow, and surrounded by steep and rocky banks. Many of those vallies are fertile, being the repositories of the washings of

a great surface of mountain; but the sides of the hills and mountains are bare, and retain little or no soil. Where the mica slate, clay slate, hornblende and primitive limestone prevail, the soil will most probably be more adhesive, accumulate quicker, and form a thicker bed. Where granite, gneiss, quartz, and other siliceous rocks prevail, the soil will most probably be light and thin.

From the mountains to the westward the country declines gradually to the sea coast, where there are but few hills; yet the surface is rugged and broken, obstructed in many places by large blocks of rocks, chiefly granite, heaped on the surface of a soil, rather sandy and light, which is tolerable the first four or five years after it is cleared of wood, but would require manure afterwards to make it productive.

A proper proportion of heat and moisture is requisite for the production of all plants, but the grasses require more especially moisture. It would appear that the New England states are best fitted for a grazing country, and moisture becomes more necessary for such a country, than for a wheat or Indian corn country. The clearing away the woods, favours the accumulation of heat in the earth, but decreases the quantity of vapour, that in passing would be condensed into rain. It would therefore seem to be prudent in such countries, not to clear more land than is positively necessary, and on no account to cut down the trees that crown the tops of the hills and mountains; for by baring their tops, the summer temperature

will be so much increased, that the clouds will pass over them without condensing, and the effects which are produced in the islands of the West Indies, by cutting away the woods, will take place on this continent, though not in so great a degree.

Between Rhode Island and Boston, the transition will most probably be covered with a soil rather fertile, where the grey wacke schist and limestone prevail; and only tolerable, where the grey wacke with large pebbles is found, but on the whole, better than the upland of any primitive soil.

The oldest red sandstone on the Connecticut river, when level, which it generally is, ought to produce a good soil where it is covered with ridges of greenstone trap; but a gradually thin soil, where the irregular declivities and trappose division of the rock, prevents the accumulation of earth sufficiently quick to form a permanent soil.

The sea coast, is, agreeably to the general character of the primitive class, little obstructed by banks or shoals, and the harbours are open, large and commodious, of easy access, with plenty of water, and safe; but the internal navigation by the rivers is exceedingly bad, full of rocks and rapids, difficult to remove; while the hard and adhesive nature of the rock, is a great hindrance to the cutting of canals.

Where the oldest red sandstone occupies the banks of the Connecticut river, from the frontiers of Vermont to below Middletown, the navigation is tolerable, approaching a little to the

advantages generally attending that class of rocks; but further up the river, in Vermont or New Hampshire, where the river runs over primitive rocks, the falls and rapids are both greater, and occur more frequently.

Vermont lays to the westward of the New England states, and occupies part of that range of mountains, running north and south in the direction of the stratification, nearly twenty to thirty miles from Lake Champlain, and parallel to it. Two classes of rocks occupy the whole state; the transition which extends along Lake Champlain, and is about twenty-five miles broad, where the primitive begins, and continues till it joins the frontiers of New England.

In the transition, the soil will most probably be good, where the land is level and composed of grey wacke schist and limestone; the siliceous members of the transition class occupying in general the mountains, will most probably be thin and sandy, though in level places the soil may be tolerable, owing to the declination from the horizon mixing the alternating strata.

The primitive, which forms the east side of the state, is principally composed of mica and clay slate, which may form a compact and strong soil in the vallies; the sides of the mountains will most probably be thin and light soil, not sufficiently thick to produce much vegetation.

Through the whole of this state, as well as the New England states, the range of the mountains runs from north to south, and of course all the vallies of any consequence follow the

same direction; open to the north and north-west winds, they are equally exposed to the south and south-west, taking immediately the temperature of those two contrary currents of air. Vallies thus situated, are subject to have a very hot summer and cold winter, and also to the great evil of a vacillating spring and autumn, where heat and cold alternate so quickly, as to injure materially all vegetables, but more particularly those of foreign origin, which is the case with most of the plants that are cultivated in the United States.

To the south-west of the Hudson river this inequality of climate is moderated a little by the chain of mountains, as well as the principal vallies, running south-east,* and consequently

* The same difference of climate is observable between Italy and Spain. In Italy the chain of the Apennines runs nearly north and south, leaving a free passage to the northerly winds to carry their temperature into all the great vallies; but in Spain the Sierra Novada, and many of the ranges of mountains, like the Pyrenees, run from east to west, and protect all to the south of them, from the sudden variations of climate, which frequently occurs in Italy during the winter. Nice, for the same reason, is considered to have the mildest winter of any place in the south of France, being under shelter of the Alps, which run towards the east on the north side, and screen the town from the northerly winds. Tokay produces what is called the finest wines in Europe, and is only a degree south of Poland, where there is no species of wine; it owes this to the chain of the Carpathian mountains, running east and west, and protecting Hungary from the rigour of the north winds. Even the polar climate of the great plain of Tartary, may perhaps be owing to the ranges of mountains running towards the Frozen ocean, while the great vallies, through which the rivers Obi, Lena, Tenisey, &c. run their long rapid courses, may serve as conductors of the

in some measure sheltered from the sudden changes produced by the north and north-west winds in spring and fall.

All circulation of heavy and cumbersome articles, such as are used for manure, is exceedingly difficult in the interior of this state, as the rivers are full of falls and rapids; but Lake Champlain facilitates considerably the exportation of their surplus produce; they also have the advantage of the tide navigation of the Hudson, for taking their produce to market.

The state of New York consists partly of alluvial, and partly of primitive, transition, and secondary rocks, and enjoys a tide navigation on the Hudson river, which penetrates through the whole classes.

Long island forms the alluvial part of the state, and has all the advantages of being a low level country, which is generally attached to this class. The west end of this island is partly made up of the alluvial, washed down by the Hudson from a transition and secondary country, and may be considered as forming a soil favourable to vegetable production, where the action of the waves has not washed away the lightest and most productive part of it.

temperature of the poles to their sources, and the same chains of mountains, which by running east and west, protect Indostan from the northern blast, may equally prevent Tartary and Siberia from enjoying the vivifying influence of the southern breezes. It is probable, that much of the climate of all countries depends on the currents of air and water, and their direction is perhaps regulated by the mountains on shore, and the banks, and other obstructions at sea, as well as by periodical winds.

The east end of the island, formed principally by the alluvial of the sea, joined to a proportion of alluvial furnished by rivers, such as the Connecticut, that run through the primitive, is most probably light and sandy, with extensive beds of gravel, too poor to produce a sufficient growth of trees or plants to enrich the soil; but enjoying the advantages of an even surface, not liable to wash; and likewise the moderate and equal climate of a low island, surrounded by the sea; hence it is capable of being made productive in pasture lands, like all the islands on this coast, which are favourable to the breeding of sheep bearing fine wool.

York island, and the Highlands, as far as Newbury and Philiptown, on Hudson river to the north, and the boundaries of Connecticut to the east, is primitive. From the town to the commencement of the Highlands we find principally gneiss and granite, and of course it inclines towards a gravelly and thin soil; the Highlands as well as the primitive which skirts the Connecticut border, contains much clay and mica slate, and will most probably form a stronger soil in the vallies.

That mass of country north of the Mohawk, bounded by Lake Champlain to the east, and the river St. Lawrence to the north, is likewise primitive; and from all appearance is a rough mountainous country, with some vallies of tolerable soil; but the mountains are most probably thin and poor, subject to the northern winds, and the rigorous changes of climate, which are the natural consequences.

From Philiptown on the Hudson, to near Lake Champlain, is a strip of transition from fifteen to twenty-five miles wide on the east side of the Hudson, and extending on the west side perhaps further; though in many places west of the Hudson, on the tops of mountains and rising grounds, it is covered by secondary, forming a constant alternation between transition and secondary, which would require much accurate examination to designate; we have therefore coloured the whole as transition, which we consider the foundation.

This valley, divided by the Hudson, ought to have a good soil, where it is level, consisting principally of grey wacke slate and limestone; but is subject to the inconvenience of the Vermont vallies, in being open to the north, and liable to sudden and great changes in the temperature. The advantage of a tide navigation, running almost the whole length, is all important to the progress of agriculture, by transporting, at an easy expense, the bulky articles necessary to improve the soil.

The secondary of this state, runs along the Mohawk to Lake Ontario, and follows the borders of the lakes to the frontiers of Pennsylvania, skirting the transition to the south-east; it is generally tolerable soil, the alluvial of the rivers being composed of depositions from the decomposed secondary; is in most places rich and fertile, as on the Mohawk, &c. The alluvial of the lakes, in many places washed by the movement of the waters, is but thin and inclined to be sandy. How far the alluvial of the lakes

extends to the south depends on how far the lakes themselves have covered those countries formerly; which is uncertain.

This secondary makes rather a small exception to the general rule of that class, possessing the properties of easy and safe navigation in the interior, owing to its small rivers running principally into Lake Ontario, which is so considerably below the general level of the country, that the streams are rapid and often obstructed by the falls. The communication with the sea, either by the lake and the St. Lawrence, or by the Mohawk and Hudson rivers, is but slightly obstructed with rapids and rocks. From the western part it is probable that the communication through French creek, the Ohio, and down the Mississippi to the gulf of Mexico, is perhaps the most easy and convenient passage to the sea.

A canal from Lake Erie to the Mohawk has been projected. So great a distance, across all the vallies made by all the streams, which run into the Lake Ontario, would make it an expensive undertaking; so much so, that it is probable the whole surplus produce that would pass through it would not pay one per cent. on the sum expended, in making it. The quantity of surplus produce to feed the idle, or to export to foreign countries, depends on the quantity consumed by the farmers and labourers at home. In this country, where they eat animal food, and every thing of the best kind, three times a day, the surplus produced by three or four labourers is not equal to the surplus pro-

duced by one labourer in countries where they eat nothing but brown bread and potatoes; where the labourers are slaves; where consumption is restricted to a few quarts of corn a week. In such places, the surplus produce destined to feed their masters and for exportation, is considerable. If all the produce made by the slave states, and exported by them, or through the medium of the other states, could be deducted from the whole exports of the United States, the balance exported by the free labour states, would be much smaller than most people are aware of.

While the labourer lives so well, and consumes such a great proportion of the produce of his labour, those statesmen and others who judge of the capability of this community to pay taxes, and feed the unproductive classes, from what takes place in Europe, will be much mistaken. No produce can possibly supply more to the non-productive class, than the surplus that remains to the farmer, after furnishing every thing his habits make necessary to feed himself and family; where those habits are like those of the labourers in most parts of Europe, they can furnish four times more surplus, out of the same produce, than the labourer can here with his present habits.

Jersey consists of alluvial along the sea coast, which runs along the east bank of the Delaware from Cape May to Trenton; and from thence to Elizabethtown it is bounded by the red sandstone. It is of course partly formed by the sea and partly by the depositions of the Hudson and

Delaware rivers, which touch two sides of it; the part of this alluvial, formed by the above mentioned rivers, consisting of depositions washed off the transition and secondary formations, is most probably good soil; but the part of it thrown up by the waves of the sea, will be thin and sandy.

Considerable depositions of bog-iron ore, are found in this alluvial, which may perhaps be owing to the vicinity of the old red sandstone, the iron oxyd of its cement furnishing the materials. So, the bog-iron ore is more abundant in the alluvial of Maryland and the Jerseys, where the red sandstone is found in the neighbourhood, than in other states to the south.

The oldest red sandstone extends from the edge of the alluvial to the foot of the primitive mountains, and from the Hudson to the Delaware. Where the country is level, and consists of the red sandstone only, the soil is good; where it is covered with the greenstone trap, it is generally thin soil and stony.

To the north-west the primitive range occupies the frontier of the state, diminishing in breadth as it progresses to the south-west, and finishes in a point south of Bethlehem. This primitive is rugged and steril, where the mountains are steep and precipitous, or where the quartz and siliceous rocks predominate. The slates, hornblende, and primitive limestone, where level, form a tolerable soil; it is likewise rich in fine magnetic iron ore, which has been wrought to advantage; but is deprived, like the greatest part of primitive ranges, of

river navigation; a great hindrance to the progress of agriculture as well as manufactories, from which disadvantage the secondary and alluvial of this state, is in some measure free.

Pennsylvania consists principally of transition and secondary, having the smallest quantity of the primitive class of any state east of the mountains, and most probably the greatest quantity of good land, in proportion to its surface, of any of the Atlantic states.

From the south-east boundary, to about twenty or twenty-five miles north-west, is included all the primitive of the state, which is light and indifferent, where the gneiss, granite or serpentine prevails; the limestone or hornblende rocks may form a tolerable soil, as the country, though broken, is not hilly, and has nothing that can be called a mountain. The rivers Susquehannah, Schuylkill, Delaware, or any other inferior streams, where alluvial is formed, being the depositions from transition and secondary formations, will most probably produce a rich soil.

An extensive transition formation succeeds to the primitive and occupies nearly seventy miles in breadth to the top of the dividing ridge, between the western and the eastern waters, which forms the summit of the Alleghany mountains. In this place the transition is wider than in any other part of our range of mountains, and is only interrupted for about twenty or thirty miles, between Norristown and Reading, by being covered by the oldest red sandstone formation.

The soil, through the whole of this tract,

when level, is tolerably good; where formed by the alluvial of the rivers, it is generally rich and fertile, but the quartzy and siliceous aggregates, which most frequently occupy the mountains, decompose into a light sandy soil, though the vallies between those mountains are rich and productive.

The river navigation of the primitive and transition of this state is, agreeable to the general character of those classes, very indifferent, obstructed by a great many rapids and falls, liable to the freshets of mountain torrents, breaking through narrow and rocky passages, with all the extremes aud inconvenience of too much or too little water, to remove which would require much labour and expense, which perhaps could only be repaid by the transportation of some very bulky articles, such as coal, gypsum, or limestone. It is a query whether an expensive canal navigation can be repaid by the mere transportation of the surplus produce of the soil, or even of manufactories, except bulky coal. Limestone, iron and manures, it is probable, support the greatest part of the expense of canals, even in England.

From the top of the Alleghany mountains to Lake Erie, is part of the great secondary formation of the basin of the Mississippi, and extends from the frontier of the state of New York to the limits of Ohio and state of Virginia; this secondary formation may incline to be sandy on the hills, where the sandstone prevails; but the valley and river alluvial is rich and fertile. It loses little of the vegetable

mould by washing, owing to its general horizontal position; and the accumulation of such vegetable manure is in proportion to the time the trees have been growing on the soil. It is probable that the alluvial made by the washing of the lake, may be thin and sandy, as well as the part that may have been at no very distant period the bottom of the lake; and for that reason the trees may not have been long enough on the surface to accumulate a bed of vegetable decomposition of any great thickness; in that case, though the earthy part of the soil may be good, the natural manure, dropped from the trees, may be thin and soon worn away.

Both coal and limestone have been found in great abundance on the west side of the Alleghany mountains; the coal they use with advantage as manure; the slaty clay, which alternates so often with the limestone in this formation, contains carbon, which augments its productive quality when decomposed into soil.

Though nearly fifteen hundred miles from the sea, it enjoys a river navigation, without any siliceous obstructions, the whole distance; as the secondary extends to the bay of Mexico, and affords all the advantages of deep and slow running rivers (which is generally the character of this class of rocks) facilitating every kind of internal navigation.

From the ease with which they navigate the small creeks and streams, every farmer may have a landing place near his plantation, and receive at small expense the limestone, plais-

ter, or coals, necessary to agriculture and the other arts. Even where a canal is necessary in this class, the level situation and nature of the rocks, makes the accomplishment of it easier than in most of the other classes.

There is no ridge of mountains on this side Lake Erie that can shelter the country from the north and north-west winds; it is therefore probable that this part of the great basin is exposed to the sudden and great changes of temperature, produced by the rapid currents of air from north to south, or from south to north; it is equally in the nature of such a situation for the changes to be more rapid and more severe, in proportion as the land is cleared of wood. Prudence might perhaps dictate the leaving strips of wood from east to west, on purpose to protect as much as possible the useful plants from the effects of the rapid changes in the spring and fall.

The state of Pennsylvania is perhaps the best cultivated of all the states in the union; that is, more of the farmers have dropped the ancient practice of wearing out one field, and going to clear away the trees of another, without adopting any system of manuring by plaister, or rotation of crops, so as to keep the lands once cleared continually in heart. Most of the Pennsylvania farmers, like the farmers in Europe, make their fields better and richer in proportion to the time they have been in culture; it is therefore partly to art and industry, and partly to nature, that we are indebted for the pros-

perous state of agriculture in this commonwealth.

Delaware, the smallest state of the union, consists almost entirely of alluvial; the part formed by the depositions of the Delaware, will most probably be good soil, while that made by the washings of the sea will be light and sandy. That small strip of primitive, which touches the Pennsylvania frontier, being low and level, is more or less covered with alluvial, and is likely to be tolerable soil.

The tide water of the Delaware, and small rivers and creeks in the alluvial, furnishes this state with good internal navigation.

Almost surrounded by tide water, this state has access to the sea at all points, and enjoys, from its being placed between the Delaware, the sea, and the Chesapeak, almost the mildness of an insular situation, not so subject to extremes of heat and cold.

Maryland has a great deal of alluvial, some primitive and transition, and very little secondary. The Chesapeak is the large inland bay, formed most probably by the ocean throwing up a bank of sand and gravel on the eastern shore; on the inside of which the great rivers, that now run into the bay, have been constantly heaping their depositions, consisting of the washings of a great transition and secondary country, which descend with the waters of the Susquehannah and Potomac, and the sediment of the Rappahannock and James rivers, consisting of transition and primitive deposition.

It is therefore probable, that the alluvial of both sides of the Chesapeak, protected by the neck of land on the eastern shore from the washing of the waves of the sea, will be good soil generally, and approach nearer to the quality of river bottoms, than any alluvial open to the movements of the sea, and liable to be washed by it. The situation in which we now find it, after so long a practice of so ruinous a system of culture, constant cropping, and no manure, is a strong proof of the original good quality of the soil.

Such is the nature of the alluvial in Maryland, occupying all the state south-east of a line drawn from Havre de Grace on the Susquehannah, passing through Baltimore to Washington on the Potomac. For navigation, both internal and external, the alluvial of Maryland enjoys all the advantages attached to that class of rocks, in an easy and safe access to the sea by the Potomac and Chesapeak bay, and a free circulation of craft in the interior by means of all the small rivers and creeks, through which the tide mounts to the foot of the granite ridge, that is, to the entrance upon the primitive.

This primitive begins at the line where the alluvial ends, and continues towards the north-west, from twenty to twenty-five miles; the country rugged but level; in some places thin and poor, in others tolerable, as it approaches the old red sandstone; a band of which, eight or ten miles wide, lays upon the outer edge before we come upon the transition; this band

of red sandstone makes good soil, where the sandstone prevails, but rather thin and light soil, where the greenstone trap covers it.

The west part of the state is a strip along the banks of the Potomac, of transition, which is most probably good soil. So great a proportion of this state laying upon tide water, intersected by the Chesapeak, and so many bays and creeks, will probably diminish the rigour of the winter, and modify the extremes of heat and cold in the spring and fall.

Virginia contains all the classes of rocks, and like Pennsylvania stretches considerably into the secondary basin of the Mississippi. The alluvial occupies all that part of the state situated on the south east side of a line drawn from Washington through Fredericksburg, Richmond, and Petersburg, to the Roanoke, having the sea for its south-east boundary. On the northern part it is good soil, like the alluvial of Maryland, but towards the south it is partly made up of the alluvial of the ocean, and partly of the deposits brought down by the Rappahannock and James rivers, collected principally from primitive countries, mostly of sand and gravel; of course, the probability is, that the soil towards North Carolina will be sandy and thin.

Both the internal and external navigation is excellent; for the tide flows up all the small rivers and creeks to the limits of the alluvial or commencement of the primitive; and the vast influx and reflux of the tide into the Chesapeak, sweeps the channels between the capes

so clear of banks, as to afford water of sufficient depth for any ship; which is rather contrary to the general effects produced on alluvial coasts.

The primitive succeeds to the alluvial, and runs north-west to the Blue Ridge, which it keeps as a boundary to Magotty Gap; from thence it proceeds south-west, and passes to the eastward of the lead mines at Austinville, and from thence towards the warm springs in North Carolina. The vallies in this, like all other primitive, are narrow, but generally rich and fertile. The upland, as far west as the South or Green mountains, is rather level, but broken; the soil thin and light near to the Green mountains; ranging in the same direction, is the red soil, which crosses the state, seldom extending twenty miles in width, or much less than six to seven miles broad; frequently irregular and in patches, and is perhaps the best upland soil, independent of river bottoms, that is in the Atlantic states.

This bed of red soil follows a narrow stratum of grey wacke slate and transition limestone, and in many places it covers the primitive at some distance from the limestone, yet it is more than probable, that it is the remains of a transition formation, which may have formerly covered the primitive to a greater extent.

Westward of the red soil, the soil is thin as long as the Blue Ridge is the boundary, to Magotty Gap; but after the ridge is primitive, to the south of Magotty Gap, there is a considerable extent of gravel, covering the foot of the ridge, called the gravel ridges, which being com-

posed of rolled quartz, apparently the remains of a great field of clay slate, mixed with a great quantity of transition sandstone pebbles, the soil is barren and thin, producing no growth of wood sufficient to manure it. Those gravel ridges continue along the foot of the primitive mountains, through both North Carolina and Georgia.

The navigation is indifferent, though below the ridge, from the level situation of the country, boats run upon James river.

On the limits of the primitive begins the transition, which continues west of the top of the Alleghany, near the Sulphur springs; from thence south-west to the eastward of Abingdon, passing about twenty-two miles west of the Painted rock on the frontiers of North Carolina and Tennessee. This is rather a broken, mountainous country, with extensive vallies of limestone and slate, which produces good fertile soil, while the mountains, consisting principally of sandstone and quartzy aggregates, make a thin, poor soil; the navigation being bad, owing to the want of water near the sources of the rivers, and the obstructions of falls and rapids hinders equally internal circulation and external communication with a market; resembling in this, the whole country which occupies the dividing range between the eastern and western waters; that is, to be further from a market than those lands situated either east or west on a navigable river.

Between the limits of the transition and the river Ohio, is the secondary of this state, which

enjoys the soil and advantages of the secondary of Pennsylvania, except as to the rivers that water it. The Great Kanhawa and other streams rise in a mountainous transition country, and may probably carry down and deposit masses of gravel, formed by the quartzy aggregates and sandstone, which frequently occupies the high lands in transition countries; whereas all the rivers in the Pennsylvania secondary, rise and run their whole course in the secondary, and are therefore more likely to make deposits, that are richer and more adapted to vegetable production.

North Carolina consists principally of alluvial and primitive, divided by a line running to the west of Halifax and the east of Raleigh, passing by Aversboro' and Rockingham. To the east of this line, extending to the sea, runs the alluvial formation. From the circumstance of this alluvial being made by the washing of the waves of the sea, or accumulated by the depositions from rivers which have run their whole course through a primitive country, the probability is, that it will in many places be sandy and thin soil.

That part of the coast bordering on Pimlico and Albemarle sounds, being protected by the sand banks and bars from the washing of the waves of the sea, may deposit a tolerable alluvial, approaching in quality to that of the Chesapeak; if the same bars and banks did not obstruct the draining of the low lands that surround those inlets, and render them too watery for the purpose of agriculture: though from the

heat of the climate it is probable, when united to a sufficient moisture, the accumulation of vegetable productions will be rapid.

From this increasing heat, as we go south, a considerable increase of vegetable production must accumulate in the low lands, where there is moisture; and on the contrary, where there is sand and no moisture, the sterility must be augmented, which will have the effect of rendering the poor lands, that are dry, less productive, and the low lands that have moisture, more rich and fertile; producing a much greater contrast between the rich and the poor soils, than takes place in the northern latitudes.

Internal navigation is good, and all kinds of manures and bulky articles can circulate through the creeks and rivers at small expense; but the communication with the sea is obstructed by sand banks and bars, which makes the export of their surplus to foreign countries, difficult and expensive.

From the limits of the alluvial to within ten miles of the frontiers of the Tennessee, all is primitive. For some distance westward, it is rather level, and covered with a coat of alluvial, which in some places forms a tolerable soil; the country afterwards becomes broken, with much granite and gneiss, forming a thin soil to the foot of the mountains, where the gravel ridges begin; being steril and unproductive. The mountains are high and rugged, rather bare of soil; the vallies, as in all primitive, narrow, but fertile. It is in this state, that the whole mass of mountains begins to be pri-

mitive, as in New England; they are therefore more steep and rocky, and the vallies fewer and narrower; they constitute the dividing ridge, and the rivers which run to the westward pass through a considerable extent of primitive country, as well as those which drain the water off to the eastward.

Navigation, both internal and external, is bad; the rivers are incumbered with falls and rapids. The strip of transition of about ten miles broad, which touches the frontiers of Tennessee, is a rough, mountainous country, consisting of the quartzy aggregates in the high lands, and of course their soils; but the vallies, though confined and narrow, are fertile and productive.

South Carolina is entirely formed of alluvial and primitive, divided by a line, running by Columbia to Savannah; the alluvial extending east from that line to the sea. This alluvial is formed by the washing of the sea and by the sediment of rivers, which have their sources and run the greatest part of their course through primitive; it is therefore probable, that the dry part of the alluvial will incline to be sandy and light soil. The river bottoms and low situations, where there is water, will be rich and fertile, from the heat and moisture accumulating so rapidly the vegetable matter. It is likewise probable, that the remains of the madrepore rocks, which are equal to powdered limestone, may be brought by the currents from the south, and mixed with the sand on the sea islands, by which the nature of the soil would be materially changed for the better. The quantity of co-

ral and madrepore rocks, that are forming on both sides of the gulf stream, where it passes the coast of Florida, gives probability to this conjecture.

The bed of blue marl, with shells, which crosses this state and Georgia, and extends even through the Floridas, will be likely to form a soil equal to limestone land; it is deposited by the sea, most probably in places protected by sand banks from the washing of the waves, and approaching to the alluvial made by the rivers.

Though the tide of the rivers ceases to flow twenty or thirty miles below the primitive, yet the navigation for craft is good to the edge of the primitive rocks, and the communication with the sea is tolerable by the means of bar harbours.

The primitive in this state, as North Carolina, is flat for some distance from the edge of the alluvial, and covered with a coat of earth, apparently the decomposition of hornblende and slate rocks, which makes a good soil, and becomes more rugged and broken as you proceed towards the mountains, which are high and steep, composed principally of gneiss and granite, and forming a thin soil, disposed to be gravelly; but the vallies or river bottoms, though narrow, are rich and fertile, diminishing in extent and number, as you proceed higher up the mountains, where the rapidity of the rivers gives little lime or still water to form the deposition of any other but heavy substances, such as rolled rocks or gravel.

The navigation in this, like the other primitive countries, is bad; the rivers, obstructed with falls and shoals, are too rapid and uncertain.

That part of the primitive which touches the alluvial, or the eastern and lowest edge, becomes flatter and more inclined to decomposition, as you proceed south on this and the two bordering states, at the junction of the primitive and alluvial; the former is decomposed to a considerable thickness below the surface, though covered with a considerable depth of alluvial; and above the junction where the primitive rocks appear in all the rivers and water courses, the surface is flat, and overlaid by a considerable mass of earth, for many miles to the westward. It is therefore probable, that heat facilitates the decomposition of primitive rocks more than water, and that the result of the decomposition, that is, the soil it makes, is more favourable to the production of vegetable matter, inasmuch as it decomposes more rapidly, and is not so liable to be washed during the operation.

Georgia, like South Carolina, consists almost entirely of alluvial and primitive; divided by a line running from Augusta by Milledgeville, Fort Hawkins, and the agency on Flint river, to the south. East of that line, to the sea and frontiers of Florida, the soil is alluvial, formed by the rivers and the sea. Some of the rivers, such as the Savannah, run through primitive country, and form sandy, light soil. The Altamaha holds the greatest part of its course

through alluvial country, and will most probably form richer and more productive depositions.

The sea may form alluvial of a superior quality, by being mixed with the broken remains of the madrepore rocks in the vicinity; it is even probable, that the islands on the coast may have madrepore and coral rocks for their foundation, which in warm climates decomposes rapidly into very good soil.

Wherever there is the command of water in this climate, vegetable matter will accumulate, which makes all the low lands on the rivers rich and fertile, though the dry land may be poor and sandy. It is however probable, that the alluvial above tide water, being level and not much washed, may be tolerable good soil. River navigation is good, and boats run up to the edge of the primitive, and coasters to the head of tide water, which is, in some of the rivers, nearly fifty miles below the primitive ridge; the communication with the sea by bar harbours is not difficult.

To the north, a little westerly of the limits of the alluvial, is the primitive formation, level, and covered with earth of tolerable quality; for some distance towards the mountains, this plateau of level country, decreases in width the further you go west, finishing in a rough, broken country. To the north it consists principally of gneiss and granite; as you approach the mountains, which are high, the soil is rather thin and poor, but the vallies between them are rich and fertile, though narrow.

A small angle of this state crosses the mountains, and touches at a point the river Tennessee; this is in part transition, and the rest secondary, which corresponds in quality with the same classes of rocks in North Carolina, and the state of Tennessee.

The part of this state, which lays upon the declivity of the Alleghany mountains, sheltered to the south from the northerly winds, and open to the mild temperature of the south and south-west breezes, ought to be, and indeed is, one of the most moderate climates of the United States; in a great measure free from the sudden and violent changes of heat and cold, produced by the free circulation of those two opposite currents of air from the north and south, bringing along with them the temperature of the opposite climates, from whence they come. It may likewise be considered as a climate more congenial to the growth of plants from the south of Europe, such as the vine and the olive, than any situation north of it in the United States.

From the circumstance of the range of mountains approaching nearer and parallel to the sea, the rivers are shorter, and run their whole course in nearly the same latitude, which renders the floods less dangerous and more under the command of dykes and barriers, than they are in the western country, where the whole basin of the Mississippi is drained by one river, and the melting of the snows in the north inundates and ravages the plains in the south, with a force and weight of water, difficult to be controlled by the limited exertions of man, and

perhaps not to be accomplished by a thin and scattered population.

The foregoing short description includes the whole Atlantic states; that is, all the states which consist of a variety of all the different classes of rocks in a geological point of view; the application of the properties whereof to agriculture, in modifying the nature and fertility of soils, is rather mixed and complicated. The rest of the United States, round by the lakes, and we have reason to believe, even as far west as the foot of the Stony mountains, consist of two classes of rocks, the secondary, and the alluvial made up of the washings of the secondary; these two classes possess properties the most favourable to the production of vegetables, first, in situation; tending always towards the level and even surface, and secondly, in component parts; being made up of particles ground and worn by repeated friction into minute powder, mixed and triturated so as to produce earths and soils best calculated for the growth of plants.

In this vast extent of country therefore, the different nature and fertility of soils does not depend as much on any difference in the quality of the rocks whereof the soils are formed in a geological point of view, for they are nearly the same, but chiefly on the difference of climate, and relative situations as to height, the regular or irregular supply of heat and moisture depending on the constancy or uncertainty of the agents that furnish them, including the various effects produced by the freshets and in-

undations of the rivers, with the nature of the rocks at their sources, and through which they may have run for some distance.

The division, called the Mississippi territory, extends from the confines of Georgia to the limits of Louisiana and the river Mississippi; and from north to south from the frontiers of Tennessee to Florida, and the gulf of Mexico. This division is composed of secondary, and the alluvial made up of the decomposition of secondary rocks; both classes of rocks contain the materials necessary to the formation of good loam, and will most probably make good soils.

That part of this district, which lays on the declivity of the hills towards the south, protected from the north wind and open to the south, will most probably enjoy an equal and moderate climate; and like the part of Georgia in a similar situation, it will be favourable to the production of the vine and the olive. Where it touches the river Mississippi, it will partake of the river alluvial, and the inconveniences of its floods and marshes; and that part bordering on Tennessee, will most probably be similar in soil, produce and climate, to the coast of the great basin which it joins.

Bounded on the west, north, and east side by navigable rivers, and drained by three other rivers that communicate immediately with the gulf of Mexico, this district ought to enjoy a good navigation, both internal and external, while it is in some measure free from the inundations and uncertainty of the rivers of long course; those rivers which have run through

it, are of a size capable of being controlled by the industry of man, and at no season subject to the inconvenience of great periodical floods, or the obstruction of ice towards their sources, which is more or less the case with those rivers that rise in northern latitudes.

From the gradual declivity of the ground, and from the rivers which run through the country, rising in a rather elevated situation at no great distance, the springs of water will most probably be abundant, and the water tolerable; the east part of the territory, with the western part of the state of Georgia, are the only body of lands in the United States, which lays on a southern coast, open to the influence of the southern breezes, and sheltered from the sudden changes which accompany the northerly winds on this continent. It may therefore be reasonably inferred, that the climate is one of the most moderate in the United States, or at least that part which has been as yet settled; and that the range of the thermometer is not so extensive, nor the extremes of heat and cold so great as in those places exposed to the influence of the northerly winds. It is equally probable, that the portion immediately south of the highest part of the termination of the Alleghany mountains will be the best protected from the influence of the north wind, and of course the most temperate climate, though the soil may be less productive from its proximity to the primitive.

The head waters of the Tennessee river, rising in a mountainous country, consisting of

primitive and transition rocks, and running a considerable distance through them, will be apt to bring down considerable quantities of sand and gravel, composed of quartz, and sandstone of transition pebbles; of course, the state of Tennessee may contain a greater quantity of gravel ridges or sand beds, than the other states in this great basin; but the state of Kentucky, made up of the alluvial that descends the Ohio, collected from a coal, grey wacke, and limestone country, will most probably be rich and fertile; the same causes will produce the same effects, with a little allowance for difference of climate, in the states of Ohio, Indiana, and Illinois. The Michigan and North Western territory, being still further north, and having more of their alluvial originating from the washing of the lakes, will require still a greater deduction from their fertility and productiveness. The whole basin consists of secondary, or alluvial resulting from secondary decompositions; and therefore has the best chance of a good natural soil, while its level situation, not liable to be washed, insures it all the benefits of an accumulation of vegetable mould, from the fall of the leaves, decayed grass, and other vegetable decompositions.

There are a great many detached masses of granite and sienite, scattered over the surface of that part of the basin, which lays to the north of the Ohio river, but runs to the south; from which it is probable, that they have come from the north, perhaps from the primitive mountains, north of the great lakes; if so, the

movement of waters must have been at some former periods different from what they are now; and those waters (in place of depositing the decomposition of secondary, as all the rivers rising near the lakes do now) most probably brought with them, along with those masses of primitive rocks, the remains of primitive mountains, and may have left more sand and gravel on the northern parts than is to be found in the south.

West of the Mississippi, the whole passes under the name of the Missouri territory, and near the sea it is called Louisiana. The whole of this territory, to near the foot of the Stony mountains, appears to be secondary; but what is the nature of the Stony mountains, or how much of the alluvial brought down from them by the large rivers (which have been the principal agents in filling up the west side of the basin) may be the washings of primitive mountains, is uncertain. The tops of the Stony mountains are covered to a considerable extent with perpetual snows and pendent glaciers; a proof that they are vastly higher than the Alleghany mountains; of course, the numberless streams and torrents, which descend their flanks, roll with much more violence and rapidity a far greater quantity of water from the melting of the snows, than can be expected to descend from mountains of the height of the Alleghany. It is therefore reasonable to suppose, that they will deposit at the foot of the Stony mountains, and for some considerable distance, a much greater quantity of sand and

gravel than the streams from the west side of the Alleghany.

This sand and gravel, when dried up by a southern sun, may form extensive basins, deprived of water; they will become deserts, while the banks of rivers or moist places may make tolerable soil. These causes may render the soil of the western part of this extensive basin unequal, and vibrating between very poor and tolerably rich.

Rivers, which rise on the mountains and run over such a vast extent of country, carrying all their waters and deposits towards one common centre, and all joining the sea by one common outlet, are generally liable to periodical inundations, and bring down with them a great body of water accompanied with a great deal of sediment or alluvial. This alluvial is generally first deposited on the bed and banks of those rivers, raising them very much above the level of the surrounding country, and giving the rivers the appearance of running upon a ridge, which is the cause why the surrounding country is liable to be flooded to a great distance by the first inundation; the draining of which, after the rivers subside, is very much impeded by the circumstance of the bed and banks of the rivers being on a higher level, and preventing the water from running off, forming large lakes and marshes, until the heat dries them up, to experience again the same drowning as at the first periodical inundation. When the weight of waters that roll down in such rivers is so great as to be out of the controul of the labour

of man, it is attended with great inconvenience and uncertainty to the farmer, and by rendering property precarious, becomes one of the greatest hindrances that can be put in the way of improvement; but this is fortunately limited in the basin of the Mississippi, to the lower part of the largest rivers, and even they, like the Nile, may perhaps be brought hereafter under the controul of persevering industry.

Though this basin is highest on the west, north, and east side, and declines gradually to the south side of the great northern lakes, there is no range of mountains or any basin sufficiently elevated to protect it against the northerly winds, which range through the whole without obstruction, and carry with them the sudden changes of temperature, common to the north winds on this continent. It is not improbable, that the frequency of those north winds may be limited by the south wind being forced up the basin by the constant effects of the trade wind, filling the bay of Mexico, and the range of mountains at the bottom of the bay turning the current to the north; still, there is a change of the opposite winds, and a sudden transition from cold to heat.

This transition of temperature may certainly become every day less injurious, both to men and vegetables, in proportion as they become habituated to the climate, and acquire new habits better fitted for their situation; for it is probable, that we have not been struggling long enough with the inequalities of the climate, to have lost our European habits; which being

forced on us by an order of things quite different, does not suit this country. Most of the vegetables, fruit, &c. which we cultivate, have likewise their European habits, which they have not yet had time enough to change.

On examining both the geographical and geological maps of the United States, it will appear, that they are divided into two distinct and separate parts, differing materially from each other in their relative situation and means of communication with the rest of the globe, as well as in their interior circulation and communication within their own territory. The national line of separation between those two great territories, is that range of mountains, called the Alleghany; which from the poorness of the soil, and the difficulty of getting to market, will most probably be the last part of the continent thickly inhabited.

On the west side of this ridge is the vast basin of the Mississippi; geologically composed of similar substances, enjoying the advantage of all climates from the 29th to the 45th degree of latitude, having the command of the tropical productions as well as those of the north, circulated through its most distant extremities by the immense ramifications of one great navigable river, communicating with the ocean only at one point; navigable with some danger and difficulty by merchant ships, but inaccessible to large ships of war.

On the Atlantic side of the ridge, they enjoy nearly the same variety of climate and production; but for the medium of communication,

from north to south, they depend on the sea, which is accessible at all points, both to merchant ships and ships of war.

The inhabitant west of the mountains is forced by situation to consider the internal navigation as the cause of his riches, independence and happiness; but having only one leading sea port, the foreign commerce will most propably be considered of secondary moment, and be given up to those who can do it cheapest. At the same time, confident of his strength, and having only one point to defend, it is difficult for his rulers to persuade him of the necessity either for a fleet or an army; so that both his situation and interest force him to be at peace with all the world.

It is not the same with the inhabitant on the shore of the Atlantic. Placed on an extensive coast, accessible at all points to the depredations of a superior fleet, he is easily persuaded by his rulers to keep up a fleet and an army to protect commerce, &c. tending doubtless to involve us in all the wars of Europe, at the enormous expense it must always cost a government such as this. Taxes follow in proportion. The inhabitants of the west pay their proportion of these taxes without the same feeling or interest. The breach widens by the natural gravitation of interest arising out of situation; and nothing can long keep them together but the utmost prudence and economy in the federal rulers, by avoiding war and every cause of expense.

On this earth, or in the page of history, it is probable no place can be found of the same extent, so well calculated to perpetuate a free and equal representative government, as the basin of the Mississippi, both from its physical advantages and the political constitutions on which the state of society is bottomed.

By enjoying the different productions of a variety of climates through a rapid and easy circulation to the extremities of the country, by means of rivers, secured against the depredations of any foreign enemy, they set out with advantages, which thousands of years of labour have not been able to obtain for other nations.

That territory, being inclosed within a chain of mountains, or lakes, together with the comparative weakness of their neighbours, guarantees the inhabitants against the least apprehension of invasion, while their having only one bad harbour, unfit for ships of war, takes away the ability of invading by sea the property of others—removes in a great measure the temptation of war—and deprives the rulers even of an excuse of keeping either a fleet or army establishment, which hitherto have always produced the ruin of free and equal representative governments.

Bottomed on a free and equal representation of men, they will most probably be governed by the majority; not like the greatest part of the Atlantic states, which are founded on a representation of property, and liable to be governed by the few or the minority. Monopoly

of property ensures monopoly of power, and the means of perpetuating it, as is proven by the experience of all other nations. They will most probably be divided into twenty or thirty free and independent representative governments, which will guarantee them against any sudden usurpation. But as all the nations in the old world who possessed any share of equal representation, have been deprived of it by the intrigues of their rulers, experience forbids the placing great confidence in the continuance of equal representation, even on this favourite spot, though we may be allowed to indulge in the hope, that it will long be governed by the positive majority, and remain a place of refuge to oppressed humanity.

EXPLANATION OF PLATE II.

THIS Plate contains five sections of the United States, from the sea shore to the great secondary basin of the Mississippi, with the comparative elevation of the range of mountains called in general the Alleghany. The scale of height on the margin is divided into ten parts; the first five is two hundred feet each, to give some apparent height to the small hills and low country; the upper half of the scale is equally divided into five, and is one thousand feet, each division; making the whole scale six thousand feet. It is not meant that the highest part of the ridge shall be found exactly where the line passes, but that the highest part of the ridge in the vicinity of that line, shall most probably be found of the height marked by the scale in the section.

The colours correspond with those on the map; that is, the Siena for the rock, red for the transition, the blue for the secondary, and the yellow for the alluvial, &c.

The Catskill mountains are here represented as transition, though in many places west of the Hudson the transition is found only on the lower ground, as the foundation; though the tops of the hills are frequently crossed with secondary.

Fig. I. No. 1. Camden in Penobscot bay, district of Maine.
2. Kennebeck river, district of Maine.
3. White Hills, New Hampshire.
4. Lake Champlain.
5. Wellsboro' on Lake Champlain.
6. Oxboro, fifty miles east of Kingston on Lake Ontario.

Fig. II. No. 1. Plymouth in Boston bay, Massachusetts.
2. Springfield on Connecticut river.
3. Green mountains.
4. Hudson river in the state of New York.
5. Catskill mountains are here represented as transition, though in many places west of the Hudson the transition is found only in

the low country, as the foundation, while the tops of the hills are frequently crossed with secondary.

6. Delhi.
7. Cayuga lake at Ithica.

Fig. III. No. 1. Egg Harbour in New Jersey.
2. A little to the S. W. of Philadelphia.
3. York in the state of Pennsylvania.
4. Summit of the Alleghany mountains.
5. Pittsburg in Pennsylvania.

Fig. IV. No. 1. Cape Henry, Chesapeak bay, Virginia.
2. Linnhaven bay do.
3. Norfolk do.
4. Smithfield do.
5. Harris do.
6. Lunebourgh do.
7. Roanoke river do.
8. Williamsville do.
9. Martinsville do.
10. Greenville do.
11. Abingdon do.

Fig. V. No. 1. Cape Fear in North Carolina.
2. Smithville do.
3. Pedee river do.
4. Catawba river do.
5. Union do.
6. Warm Springs, near the frontiers of Tennessee.

ESSAY

ON THE

FORMATION OF ROCKS,

OR AN

INQUIRY INTO THE PROBABLE ORIGIN

OF THEIR

PRESENT FORM AND STRUCTURE.

BY

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ESSAY

ON THE

FORMATION OF ROCKS, &c.

Essay on the FORMATION OF ROCKS, *or an Inquiry into the probable Origin of their present Form and Structure.*

Our knowledge of the actual and present state of the substances which constitute our globe, is unfortunately confined to a small portion of the surface; from which it would appear, that we are still very deficient even as to those facts which are within the reach of our observation and experience, and which may perhaps be necessary to the forming of any rational conjecture concerning the formation or former state of those substances which cover the external surface of the globe.

Concerning the nature and properties of the great mass which constitutes the interior of the earth, we are entirely ignorant; few of our mines penetrate deeper than one fifty thousandth part of the earth's diameter under the surface, and none of them go beyond one twenty-five thousandth part of that diameter: it would appear, therefore,

that any mere supposition concerning the actual and present state, or the nature of those substances which form the interior of the earth, is unsupported as yet by any reasonable analogy; and that all conjectures concerning former changes, partial or total, in the nature and structure of those substances, are removed still farther from any thing analogous in our present state of knowledge.

The earth being flattened at the poles, does not necessarily imply its former fluidity; we may be permitted to doubt the analogy between our experiments on bodies moving in our atmosphere, and the earth's motion in space: our total ignorance of the nature of the fluid which occupies what is usually called space, tends to render the analogy inconclusive.

May not the mode of casting patent shot be considered as an experiment on the form which liquid bodies would take by a rotary motion? A drop of melted lead let fall from the height of two hundred feet is completely globular, and not flattened at the poles; the lead might be thrown with force from the top of the tower, which would imitate the centrifugal force, as gravitation does the centripetal force, and make the experiment more analogous.

The supposition that the earth was in a fluid state when it took its present form, leads to the supposition that it was always so; and that fluidity was the original state of the earth, kept so by all the general laws and order of nature, all of which general order and laws of nature must be totally changed before the earth would take a solid form.

On the supposition that the earth, previous to its fluid state, had existed always in a solid state, and that some creation or accident produced the fire or water necessary to its liquefaction, we have in that case first to suppose, that the order and

nature of the general laws which had kept it always in a solid state, were totally changed, to produce a fluid state; and that another change in the general laws which produced and kept it in a fluid state, must have taken place previous to its having become again solid.

It may be doubted, whether the uniformity, order and regularity of the general laws of nature, which have at any time come within the limits of our observation, can warrant a supposition, founded on such complete changes in the mode of action.

The Neptunists admit the fluidity of the earth, and endeavor to prove that water must have been the cause of that fluidity; though to *dissolve* the greater part of the substances now found on the surface, or as far under it as we have yet penetrated, would require two or three thousand times more water than the solid contents of the whole globe. How nature has disposed of that immense quantity of water, now become unnecessary by the consolidation of the globe, is but one of the many difficulties which arise out of the Neptunian system.

The Volcanists, likewise, consider the fluidity of the globe as a necessary foundation for their system; but insist that fire must have been the cause of it, nor can they, in a satisfactory manner, dispose of the immense quantity of caloric or heat, become unnecessary by the consolidation of the globe: difficulties that must always attend suppositions of a total change in the general laws of nature, because the agents necessary to the retaining of matter in one state, must be disposed of before that matter can acquire a different form or nature.

It is, perhaps, an historical fact, that all geologists who have formed their system on the examination of the northern parts of the continent of Europe,

where there are no existing volcanoes, are Neptunists; and those who have examined Italy, or other volcanic countries, previous to the formation of their systems, are more or less Volcanists, which tends to prove, that opinions are the result of our knowledge, and our knowledge the consequence of the different situations which chance or choice has thrown us into: we ought, therefore, not to be astonished, much less irritated, at the difference of opinions, but consider them as the natural effect or consequence of our locality or opportunities.

Suppose the earth was a body of moderate size, that we could cut up and dissect as we do animals, vegetables; or other objects of natural history, it is probable that the first part which would attract our attention would be the volcanoes, in action, with the mountains formed by the ejected matter; we should probably first examine this ejected matter, to ascertain what proportion of the surface of the globe, or ball, was covered with similar matter: we should, of course, find out the extinct volcanoes, and though the fire had ceased to act, the similarity and relative position of the matter would induce us to conclude that they were produced in the same manner, as well as the small detached remains of similar substances, which we would find scattered over the whole surface.

After shaving off all that we supposed to be formed by fire, the next active agent that would attract our attention would be water. The productions and changes wrought by the operation of this agent, would be examined: the aggregates of rounded particles, deposition with organic matter, &c. would be considered as belonging to formations by water.

Clearing the surface of the ball with our dissecting chisel of all that we could ascertain by analogy to belong to the formation by water, or fire, we

would come to a species of matter that did not exactly resemble either of the above formations, which, on examining, we would find of various textures; and comparing it with the portions already cut off, we would find part of this matter which had a distinct resemblance to that formed by fire, and part to that formed by water, but so mixed and confused together as to prevent our forming any distinct conclusions. After turning the ball two or three times, we would naturally wish to know what constituted the interior or central part; for which purpose we would cut it in two, and expose the interior to our examination and analysis, as we had before examined the exterior; and if we should find that the interior was fluid, and like a soft boiled egg, and only the exterior was solid, we might follow the analogy of the egg a little farther, and deduce the probability, that at some former period the exterior crust had been fluid, and had since become solid, by some operation of nature analogous to something we had ourselves observed.

On the contrary, should the examination of the interior of the ball, prove, that it consisted of a variety of solid substances, farther and farther removed from any resemblance with those we had observed as formed on the surface by fire or water, we should probably conclude, that these agents were not necessarily instrumental in the formation of those substances; and that we were totally ignorant of the process which nature may have adopted to form those substances, and we should doubt whether those substances had not always existed in that state. Thus would the investigation be left, until farther dissections, and the analysis of similar constituted balls, had thrown more light on the subject of our inquiries.

In this manner the examination of the origin of the rocks that form the external crust of our globe

ought, perhaps, to be conducted; beginning with those substances that have been formed under the immediate evidence of our senses, and completely within the limits of our observation, either by water or fire, and proceeding to others having a direct resemblance, in structure, component parts, or relative situation, or united by the chain of positive analogy, to the same mode of formation; evidently deriving their origin from the action of the same agents of water or fire, until we come to the last crust, beyond which we cannot penetrate; then we must drop the thread of positive analogy, and not being able to make a cut to the centre of the globe, be content with probable conjecture.

At this point, where positive analogy finishes, and probable conjecture begins, will be the natural line which will divide the rock into *two classes;* the first class will contain all those whose origin, either by fire or water, has taken place under the evidence of our actual observation, or those that can be traced by positive analogy to the same origin. The second class comprising all those rocks which have no positive analogy with either, yet containing some parts which have a distant relation to both the modes of formation.

As nature does not advance by large leaps, but by small and regular steps, leaving no marks in the chain of gradation on which we can place the limits of our artificial division, the line of demarcation between the first and second classes will be doubtful; and the rocks approximating on both sides, will not be well determined. The line also must change with the progress of our knowledge and discoveries, and rocks placed in the second class now, because we have found analogous rocks in the first class, may change their place by new discoveries, and pass from the second to the first class, or from what may be called the unknown in-

to the known, whenever future experience and observation have thrown light on their origin.

There is no question here concerning the relative period in which the different formations by water or fire have originated. This is difficult to ascertain; and from the numberless derangements in the original order, liable to many exceptions, nor is the necessity of it evident in the inquiry concerning the origin. Nothing within our observation proves the priority of one mode of formation over the other, nor militates against the probability of one formation often alternating with another, and it is more than probable that the reason we have so few instances of such an alteration on record is because there is so small a proportion of the crust of our globe accurately examined.

In attempting to separate the rocks, whose origin comes within the sphere of our positive knowledge, or positive analogy, from those whose faint and distant resemblance leaves the nature of their origin to conjecture, I am convinced, that neither my experience, knowledge, nor industry, are adequate to the task of comparing their various differences and resemblances, so as to form an adequate conclusion; but the faults and imperfections in the execution will not, perhaps, injure the propriety of the arrangement or method; for it has always appeared to me necessary to fix some boundary between the knowledge of facts which must increase with our experience, and the field of conjecture which may, perhaps, on the contrary, diminish as our positive knowledge augments.

It is probable that nature has many more ways of effecting the changes, in the form of rocks, than we are acquainted with; and that she employs many agents, the nature and properties of which we are as yet totally ignorant of; nor is it improbable that she may form the same rock by two or

more different agents. When we pretend to limit the operations of nature, to suit our contracted ideas, we most probably do her injustice. To proceed from the known, which we see daily forming, towards the unknown, through a chain of reasoning strictly analogous, is perhaps all that our present knowledge will permit us to do.

It is not intended to give a description of all the particular rocks that may constitute a formation, or be subordinate to it, many of them, such as the topaz-rock, (which has only as yet been found in a bed, in clay slate, forty or fifty feet broad, and from two hundred to three hundred feet long) would tend to confuse: a general description of the formation, with a few observations, is all that I shall attempt.

SYNOPSIS OF THE ORIGIN OF ROCKS.

As we do not comprehend either the creation, or annihilation, of matter, by the origin of rocks, we mean the last change which produced their present form, and the agents that nature employed to give them that form, or effectuate that change.

First Class. Of Neptunian origin.

First Order. Formed by nature under our observation, visible, and resting on the evidence of our senses.

Sand beds,	Brown Coal,
Gravel beds,	Bog Iron ore,
Sea-Salt,	Calcareous Tuffa,
Sandstone,	Calcareous depositions,
Puddingstone,	Silex from Hot-Springs &c.

Second Order, resembling, in structure, position, or component parts, the first order, the evidence of their origin resting on direct and positive analogy.

Coal,	Graywacke & Graywacke slate,
Gypsum,	Transition Sandstone,
Chalk,	Transition Limestone,
Compact limestone,	Transition Gypsum,
Sandstone,	Transition Clay Slate,
Puddingstone,	Anthracite,
Rock-Salt,	Siliceous Schist.
Old Red Sandstone,	

SECOND CLASS. Volcanic origin.

First Order. Thrown out of active volcanoes, and resting on the evidence of our senses:

Compact Lava.	Mud Lava,
Porous Lava,	Obsidian or Volcanic Glass,
Porphyritic Lava,	Pumice stone,
Scoria,	Cinders, &c.

Second Order. Resembling the first order in structure, position, and component parts, having the remains of craters, with currents of lava diverging from them: though the fire, which may have formed them, is now extinct; the evidence of their origin resting on direct and positive analogy:

Basalt,	Pearlstone,
Trap formation, called by Werner the newest Flœts	Porphyry attending the Trap as above,
Trap formation,	Clinkstone ditto, &c.
Pitchstone,	

Third Order. Where the rocks resemble the second, in texture and component parts, but

where all the craters, cinders, scoriae, and most of the porous rocks, have been washed away, leaving only the solid parts, such as

Basalt,	Pitchstone,
Trap, called by Werner the newest Flœts Trap formation,	Porphry,
	Clinkstone, &c.

These rocks resemble the volcanic in relative position, covering indifferently all the other classes of rocks, and in detached pieces, without any extensive continuity or stratification, but divided by vertical fissures, the proof of their origin resting on a more distant analogy than order second.

THIRD CLASS. The origin doubtful, resembling a little the second order of the first and second classes, but the analogy neither direct nor positive, amounting only to probable conjecture.

First Order. Such rocks as probable conjecture would incline to place in the Neptunian origin:

Gneiss,	Clay Slate,
Mica Slate,	Primitive Limestone.

Second Order. Such rocks as probable conjecture would incline to place in the volcanic origin:

Hornblende,	Sienite,
Porphyry,	Granite,
Greenstone,	

The origin of rocks may first be divided into the known and the unknown. The two first classes contain the knowu, and the third class the un-

known. Farther observations may change their situation, and place a rock, which is now in the unknown class, in the known class, by which means the unknown class will diminish as our positive knowledge increases, and in proportion as the known class augments.

The first class, or those rocks whose origin comes within the limits of our positive knowledge, or can be traced by positive analogy, divides itself into the Neptunian and Volcanic, according as water or fire were instrumental in their formations.

First Order. The Neptunian or aqueous formation.

1. *Sand beds*, consisting of small particles of rocks rounded by friction or attrition.
2. *Gravel beds*, consisting of large particles of rocks; rounded by friction or attrition.
3. *Clay beds*, sediments by water, including marle, and all sediments in impalpable powder.
4. *Sea-Salt*, with all its attendants of argile, Gypsum, &c.
5. *Sandstone*, particles of sand rounded by friction, and cemented by calcareous or other infiltration into a hard adhesive rock.
6. *Puddingstone*, particles of gravel rounded by attrition, and cemented by the infiltrations of siliceous, calcareous, ferruginous, and other aqueous depositions, &c.
7. *Braunkohle Turf*, or other bituminous or vegetable substances included in the beds of the above alluvial rocks.
8. *Bog iron Ore*, Pyrites, &c. included in the above alluvial.
9. *Calcareous Tuffa*, a coarse-grained deposition from a chemical dissolution in warm springs,

&c. &c. from a rapid and suddden precipitation.

10. *Calcareous deposition*, called Travertina at Rome, from a slower precipitation, by evaporating of water, permitting it to take a compact and solid form.

11. *Silex* from siliceous precipitation: slowly as in petrified wood and other organic matter, which are solid and compact, or suddenly as from the hot springs of Iceland, where it is cellular and rather coarse grained.

The above-mentioned rocks are stratified horizontally, following the inequality of the surface on which they rest; they are found on or near the surface of the earth, and their origin is within the limit of our observation: as nature may be said to carry on her manufactory, subject to the daily inspection of our senses. They have been called alluvial rocks, by some mineralogists.

Second Order of Neptunian Rocks.

12. *Coal* formation, including the attendant strata of Puddingstone, Sandstone, Slaty Clay, Bituminous and Alluminous strata, &c. with vegetables, and other impresions of organic matter.

13. *Gypsum*, coarse-grained, composed of shells, and other organic matter, with all its attendant strata of indurated marle, sandstone, cellular, and other depositions of silex, &c. &c.

14. *Limestone*, coarse-grained, composed of shells and other organic matter, with all its attendant strata of indurated marl, sandstone, cellular and other depositions of silex, &c.

15. *Chalk*, including all the attendant substances, as siliceous depositions of flints in strata and nodules, pyrites, &c. with shells and other organic matter disseminated &c.

16. *Compact Limestone*, including every species of horizontally stratified limestone, with the remains of organic matter, as shells &c. &c. disseminated.
17. *Sandstone*, including all horizontally stratified sandstone, having organic matter, or alternating with strata including organic matter.
18. *Puddingstone*, including every species of rock formed of rolled masses horizontally stratified, having organic matter, or alternating with rocks including organic matter.
19. *Rock-salt*, including all the attendants of Clay-beds, Gypsum, Sandstone &c.
20. *Gypsum*, horizontally stratified, including Clay, Sulphur, crystals of Quartz or Aragonites, &c. &c., in which no remains of organic matter may yet have been found.
21. *Sandstone*, with an ochry, ferruginous cement, called by Werner, Rothe tode Liegend, with all its accompanying stratifications of limestone, thin strata of coal, gypsum, &c. &c. having organic matter disseminated, though rare.

The above rocks are generally stratified horizontally, or following the dip or inclination of those on which they rest, but lying deep under the surface, and their period of formation, prior to the date of our observations, prevents, their mode of aggregation from coming within the observation of our senses; and must depend on rational or positive analogy.

22. *Graywacke*, rolled masses of rocks cemented by a clay slate, more or less apparent, or by a slaty fibrous cement, having some resemblance to a chlorite slate: the last mentioned, generally found near the primitive.
23. *Graywacke slate*, small rounded particles of rocks, enveloped in a slaty base, accompanied and alternating with calcareous shist, &c. &c.

24. *Sandstone* of transition, fine grained, having generally a siliceous cement: in the fresh fracture, resembling quartz, but in a state of decomposition the granular texture appears.

25. *Limestone* of transition, generally a small crystalline grain, with small veins and seams of calc-spar, having small plates of clay slate often disseminated, &c. &c.

26. *Gypsum* of transition, having a small granular crystallization, accompanied with small plates of slate or shist.

27. *Micaceous Slate* of transition, alternating with small grained crystalline limestone: the strata consisting of a species of talcy or mica slate, and a variety of shistoze, intermediate rocks, as on the Ardennes, and the Appenines, including roofing slate, and its attendants.

28. *Anthracite* including the attendant strata of clay slate, allum slate, black chalk, &c. &c.

29. *Siliceous shist*, as Kiezel-sheiffer, Jasper, and other siliceous stratifications.

The above rocks are generally stratified, dipping or inclining from the horizon, at an angle of from 30 to 50 degrees, and in some cases even more; most of them, except perhaps the last (No. 29,) have been found to contain the remains of organic matter, though in small quantities; and are a little further removed from the first order, though still united by the chain of probable analogy to the same formation. No. 29 approaches nearer the green stones and Porphyries, where the analogy is not so conclusive.

Greenstone, including greenstone porphyries, and the hard, compact rocks on the borders of the 2d class.

Porphyries, crystals of quartz, feldspar, &c. in compact, and often small crystalline bases; found near to the limits of the first and second class, and partaking of the properties of both.

As the above rocks approach those of the second class, they gradually remove from any positive analogy to the Neptunian of the first class. They contain no remains of organic matter, nor any particles of rocks rounded by attrition; nor do they resemble any of the precipitations or depositions contained in the first order of the Neptunian rocks. They are allied to the Neptunian division, by their stratification and relative position; touching and perhaps alternating, with some rocks of the second order of the Neptunian division; in structure and external appearance, they resemble many of the members of the volcanic family, and approach in many of their properties to that species or formation of rocks, called by Werner, the trap or basalt formation, (newest flœts trap formation.) The few remarks we have to make on this order, may therefore come most properly after we have examined all the rocks united either to the Neptunian or volcanic origin, by positive or rational analogy. This will clear the field; and bring those of doubtful and conjectural origin, into a smaller compass, where their resemblance or difference can be better examined; and the result of the comparison may throw light on the third class of rocks, where positive or rational analogy is deficient.

Nature composes, forms, or aggregates those rocks either by mechanical deposition, as in sand, gravel, or clay, Nos. 1, 2, and 3; by a precipitation from a chemical solution, as in Nos. 9, 10, and 11; or by a mixture of both modes of aggregation, as in Nos. 4, 5, 6, 7, and 8. These aggregations of sandstone, puddingstone, &c., are more or less hard and adhesive, according to the nature of the precipitate which unites them; and nearly resemble the aggregates in the second order: but the depositions of impalpable powder, such as clays

&c., generally remain in a soft state, having less resemblance to the slaty and argillaceous rocks of the other orders of Neptunian origin. The calcareous precipitations are not generally so hard and adhesive as those of the second order, though they have much the same texture and external appearance; but the siliceous precipitations in petrified wood, and other forms, are equally hard and compact, having a direct analogy with the siliceous rocks of the second order; they are likewise the only species of rocks, positively known to be of Neptunian origin, which resemble a little in texture, hardness and external appearance, many of those of volcanic origin.

Rocks of the following description, may be considered of Neptunian origin by positive and rational analogy, viz.

Those containing shells and other animals, known only to exist in water, or the remains of other organic matter, destructible by fire.

Aggregates of sand or gravel, rounded by attrition, resembling those formed every day by the action of the sea, rivers and lakes.

Substances, whose structure and component parts are similar to those formed by the depositions of lakes, springs, &c. which are evident to our senses and daily observations.

Substances, alternating and intimately mixed with all, or any, of the above description, provided, nothing similar has yet been found in those, which are of undoubted volcanic origin.

FIRST CLASS.

Order II.

Of the Neptunian origin.

12. *Coal formation.* The series of aggregates which constitute this formation, are evidently of aqueous origin: the puddinstone and sandstone, are composed of particles rounded by attrition; and as well as the slaty clay, bituminous slate, &c. contain the impressions of vegetable and other organic matter, which are, as well as the coal itself, destructible by fire, rendering the analogy conclusive.

They are generally found in hollows or low situations, when compared with the surrounding strata, which may be called basins or depots, and may be divided into three different basins or depots, according to the different nature of the rocks, which form the basins or foundation on which the formation lies.

The first is the deposit in calcareous basins, or reposing on the foot of the compact calcareous mountains; such as the coals at New-Castle and Whitehaven, in the counties of Yorkshire, Lancashire, Cheshire, and in fact, the greatest part of the coals wrought in England, with the exception of some fields in Wales, which are in primitive basins; the coals in Poland, on the foot of the compact limestone of the Carpathian mountains, through Silesia, and following the calcareous chain through Germany to the Hartz; the coals at Aix la Chapelle and Liege; and perhaps all the coals in Flanders, may be found to repose in calcareous basins, or to crop out at the foot of calcareous hills. The immense beds of coal lying upon secondary limestone west of the Alleghany moun-

tains in North America, are likewise of this description. This is, perhaps, the most extensive and regular of the coal formations; the beds are generally of a moderate thickness, or from one to six feet; of great extent; a great number lying one under the other, even to 20 or 30 beds; and alternating principally with slaty clay and sandstone, with little or no puddingstone. The argillaceous ironstone so frequently wrought as an iron ore in England, is found in beds of clay in this formation.

The second repository or deposit, is found in the hollows or valleys in the primitive formation, such as the coals near Nantz, on the Allier, St. Etienne, and Rive du Guir, in France; Richmond, in the United States of America, &c. &c. These deposits are generally less extensive than the first; they are in clusters or heaps of forty or fifty feet thick, without any regularity in the stratification; often after working a forty or fifty feet bed, it runs out to a thread in fifty or one hundred yards, and recommences in another place. They alternate with, and are covered with a great proportion of puddingstone, and sandstone, and a much less proportion of slaty clay, and argil, than the first kind of deposits.

The third kind of repositories or deposits, are not so regular as the other two, and more difficult to define. They are generally found at the foot of those ranges of mountains, where the old red sandstone takes the place of the compact limestone, on the flank of the primitive; such as the coals on the south side of the mountains in Bohemia—along the chain of the Vosges—parts of those found in the south of France—and in Scotland.

The stratification of this deposit of coal, is neither extensive nor regular. It is often interrupted and broken, having frequently basalt in its neigh-

borhood, or the trap formation, which in some places covers it. It is also covered by, and alternates with, a greater proportion of sandstone; and there are comparatively, perhaps, fewer vegetable impressions, or the remains of organic matter, in the accompanying stratification.

From all this it may reasonably be concluded, that at the time these coal formations took place, the surface of the earth was partly covered by primitive, partly by transition, and partly by secondary rocks, as we find it at present.

13. *Gypsum.* This formation seems to partake of Neptunian origin, by its including the remains of organic matter; alternating with aggregates of rocks rounded by attrition, containing shells; and being found generally in a more crystalline form than the other rocks of this class, owing perhaps, to its great solubility in water; it occupies the lower situations, and is not found in mountainous countries. Such is the gypsum round Paris, at Luneburgh, and in Holstein. Perhaps some of the extensive formations of gypsum in Spain, and that in the vicinity of Jena, in Saxony, may belong to this formation.

The remains of animals have, I believe, only been found, as yet, in the extensive gypsum quarries in the vicinity of Paris; in almost any other situation, except the vicinity of a large town, it is probable that the few specimens containing such organic matter might have remained unnoticed for ages; which shows how deficient we are in the necessary knowledge of the actual state of the substances within the reach of our observation; and how few are the positive facts on which the narrow foundation of our general and sweeping systems of the earth's formation must rest.

14. *Coarse-grained Shell Limestone*, consisting of the remains of organic matter, which are now only found to exist in water, sufficiently proves its Neptunian origin, as well as that of all its accompanying strata; the silex found alternating or touching this formation, has often the impressions of organic matter, and has always the structure of the siliceous precipitates found in the first order of the Neptunian rocks.

This formation generally occupies the lower levels: it is seldom found in mountainous countries; it covers immediately both primitive and other more recent formations; it is found both in extensive and partial beds; and varies only in the nature of the shells it contains; the rock itself being much the same, either a coarse aggregate of sand and calcareous matter, resembling the calcareous tuffa of the first order of Neptunian rocks, or a kind of indurated marle, not much different in some places from chalk.

15. *Chalk formation* is analogous in structure and component parts to the disposition and precipitations of Nos. 3 and 9, of the first order of Neptunian rocks; it contains calcareous and siliceous petrifactions of organic matter, with pyrites, as in Nos. 8 and 11, so that it unites most of the different modes of precipitation, and deposition, we have observed to be followed by nature in the formation of rocks of the first order; except the aggregates of particles rounded by attrition.

Its situation is generally in flat or level countries, seldom or never found in mountainous, occupies in general extensive fields, as from the east part of Champaigne in France, to near Bath in England; and from Flanders to the vicinity of Ons; with some interruptions common to most nations. It is seldom or never found alternat-

ing with compact limestone, or with coal, or sea salts. Iron seems as yet the only metal it contains, and it is seldom or never found alternating with any kind of shist, or having any distinct or uniform stratification.

16. *Compact Limestone* resembles in structure and component parts No. 10, of the first order: it contains shells and organic remains of animals found at present to exist only in water, and of course it is by direct analogy of Neptunian origin.

This is one of the most powerful and extensive formations we know. The history of it alone would require a volume. It is found either in detached secondary hills or ranges, (as the ridges that cross England through Derbyshire) or lying on the flank of primitive or transition mountains, as the immense curtain which skirts the north and west side of the Carpathian, Bohemian, Tyrolean, and Alpine mountains, from the Black Sea to the borders of the Mediterranean; and the powerful and extensive beds which line the basin of the Mississippi on the west side of the Alleghany mountains in North America.

Where the stratum is very thick, the rock is solid and compact, containing little or no shells or other organic matter; but when the shells abound, the stratum is thinner, and the beds of shells, with some mixture of argillaceous deposits, are found in greatest quantities between the strata. These are often broken and irregular, from the great number of excavations and caverns they contain, through which run subterraneous rivers, washing away the limestone, and deranging the originally horizontal strata.

There are great varieties in the color; the fracture is sometimes earthy, but more frequently smooth, and conchoidal. It appears to be mixed

ing with clay, and other rocks of the Neptunian formation, in which the remains of organic matter have been found, must be considered as proof of its Neptunian origin.

This gypsum is generally found in the vicinity of mountains, as round the foot of the Hartz, and contains sulphur. It is also found near to Cracow in Poland, in Murcia, Granada, and at Conila, in Spain. It has quartz and arragonite crystals imbedded in it in the provinces of Arragon and Valencia, in Spain, in which kingdom this formation is extensive, but much broken and confused, having its stratification irregular and deranged, so as to be difficult to ascertain the relative situation. It is probable that the gypsum near Cognac in France, and that near Chalons on the Saone, are likewise of the same formation.

21. *Sandstone* with an iron ochrey cement. This resembles the other sandstone formation, being composed of particles of rocks rounded by attrition; in some places forming puddingstone, the sandstone serving as the cement. It includes and alternates with clay in a soft state, and with gypsum. The remains of organic matter, though rare, have been found in it, which renders the analogy conclusive, of its being of Neptunian origin.

This, like all the other sandstone formation, is liable to be washed away when exposed to the weather, and is then found in broken and detached pieces, when not protected by some more solid covering. These detached fragments require some observation, to unite and reduce to one general formation; with this necessary attention, it will be found to be rather an extensive formation, as it is in North America, covering indiscriminately different kinds of the primitive, from Connecticut

river to the Rappahanock, nearly one hundred and fifty leagues. On both sides of the Vosges to beyond Treves, it generally reposes on the porphyry, covering the porphyry of the chain of mountains in the black-forest opposite the chain of the Vosges, and equally covering the porphyry on the south side of Tyrol, from the valley of Falsa, to near Bergamo, and perhaps farther, as the same porphyry lies upon the gneiss on Lago Majore, though there the sandstone is wanting, perhaps from being washed away.

As this formation has been taken for the graywacke, and graywacke shist, by some mineralogists, it may not be useless to give here a description of the points in which they resemble, and the properties wherein they differ, according as I have observed them.

These two formations resemble each other in being united by a cement consisting mostly of argil, and taking the appearance of clay slate, when the cement abounds either in the sand stone or puddings. This sandstone likewise, as in the graywacke shist, takes a shistoze appearance, with particles of clay slate, when the cement predominates; and in situation, it is immediately following the primitive, like the graywacke shist and other transition rocks.

The two formations differ in color; the red sandstone cement containing a considerable quantity of the red oxide of iron; in hardness, the red sandstone being much softer and less adhesive. The red standstone has no veins of calcspar crossing the stratification, whereas the graywacke shist is generally full of little veins or threads of calcspar, crossing the strata in all directions, and alternates with beds of compact, small grained limestone, full of the same veins of calcspar; the red sandstone has no such limestone; but a thin stra-

tum of a kind of argillaceous limestone or indurated marle, occasionally divides the strata of sandstone; the graywacke shist runs into, and alternates with clay slate, and roofing slate, and goes by a gradual transition into the primitive slate and hornblende rocks, but the red sandstone has no clay or roofing slate in or near it, and generally lies upon the primitive, without any gradation of transition; it is seldom or never found near the graywacke, nor often on the same side of the range of mountains, though when there is no graywacke, or other transition rocks, it occupies their place, and covers immediately the primitive.

The gypsum found in the red sandstone is in thin strata, alternating with much clay in a soft state; the stratum of gypsum in the transition is powerful and extensive, with the little argil it contains generally in the form of a shist or slate.

The above remarks may perhaps be applicable to what is called in France the *Gres de Houillier*, a sandstone of the coal formation, which in Flanders, and other coal countries, has some appearance of graywacke shist, and has been taken for such by many mineralogists. This *Gres de Houillier* is generally composed of sand, with small plates of mica, of a shistoze structure, but is much softer and in general the cement not so shistoze, nor does it alternate with any of the rocks generally found accompanying the graywacke shist; and though it is like the red sandstone, and has some resemblance to the formation of graywacke shist, yet the difference both in structure and position must perhaps exclude it from those formations.

Transition Neptunian Rocks.

The character which distinguishes this from the secondary, may perhaps be the nature and arrange-

ment of the cements; in the aggregates of the secondary this cement is produced by infiltration; the rounded particles generally touch each other, but in the transition, the particles when small, appear to have been swimming or floating in the cement, which seems to have prevented them from touching, and usually forms a more homogeneous mass. When the particles are large, gravitation may have overcome the resistence of the cement, and they touch; but even then the cement occupies more of the space, than in the puddings of the secondary.

The stratification of the transition rocks, seems to constitute another dividing characteristic, being generally at a dip from the horizon, and seldom or ever found horizontal; but the limits near the dividing line will, perhaps, for a long time remain doubtful.

The clay found in the sandstone of the secondary is generally in a soft state, earthy in its fracture, and has little or no resemblance to the slate, and other argillaceous rocks, mixed and alternating with the transition aggregates.

The word *transition* may not be so appropriate as *intermediate;* though in many situations the passage from these rocks to what are called primitive, is so gradual, as to render it difficult to draw the line of separation.

The application of the term transition was made by those who first introduced the division, and described the rocks included in it; whereas "intermediate" has been adopted without any regular classification of the rocks meant to be included under the denomination; from which it is probable, that in the present state of our knowledge, transition being better defined, will be better understood, which constitutes the principal utility of all names, whether of rocks or other substances.

22. *Graywacke*, an aggregate of small fragments or particles of rocks, most frequently rounded by friction or attrition; and though not generally containing the remains of organic matter itself, yet, as it alternates with other rocks in which organic matter has been found, it must be ranked by analogy as of Neptunian origin.

There are, perhaps, three species of rocks included in the above; which though united in the same kind of formation, by containing particles of rocks rounded by attrition, yet differ in the nature and relative quantity of the cement which unites them, as well as in their relative situation.

The first, and perhaps the most common, is an aggregate of different species of rounded rocks, where the cement bears a small proportion to the quantity of particles aggregated; of this kind is the graywacke of the Hartz in Saxony, and generally that species of graywacke which alternates with graywacke shist.

The second is an aggregate with a small grained, rather crystalline, cement of a greenish color, resembling a little some kinds of chlorite, which cement forms a great proportion of the rock, as in the range north of Vigo, and Bleyburg in Tryol.

The other is an aggregate of rounded quartz, seldom exceeding the size of a walnut, in a shistoze cement, inclining to be fibrous, the cement forming the principal mass of the rock; as the rock generally found on the borders of the primitive, the first aggregate in the transition formation on the west side of the primitive ridge in North America, in which the quartz is generally of a light blue color. I found in the valley of Durasa, south of Mount Rose, a rock of the same nature.

23. *Graywacke shist*, an aggregate of small particles of rocks rounded by attrition, united by a ce-

ment more or less shistoze, having remains of organic matter, (though rarely) found in it; and being consequently of Neptunian origin.

This formation, though often accompanying the grawacke, yet is much more general and extensive; it covers the north side of the Carpathian and Bohemian chain of mountains, as well as the Tyrolean and Switz Alps; increasing in force as it proceeds south along the mountains in Daupiny; it probably covers the whole chain after you pass Mount Cenis, and constitutes the greatest proportion of the Appenines from Genoa to beyond Naples.

In North America it forms the passage between the primitive and secondary, along the whole chain of mountains from north-east to south-west, on the west side of the Alleghany; and as it were, lines or sheaths the primitive along the edges of the great basin of the Mississippi, and supports the great secondary calcareous formation, which fills or occupies that basin.

It constitutes part of the mountains of the Crimea; surrounds the primitive mountains of the Hartz; is found in Wales, and Cumberland, in England; and it is probable there are few primitive mountains in Europe, between the latitudes of fifty and sixty degrees, which are not covered on one side or the other, by this formation.

The above general observations on the locality, includes the rocks which accompany and alternate with the graywacke shist, such as the clay slate of transition, the various stratification of limestone, sometimes intimately mixed in thin strata, from half an inch to two inches in thickness, and at other places alternating in powerful beds, forming almost entire mountains. Considering the graywacke shist as the most general, and best charac-

terized, of all the members of the transition family, to avoid repetition, it were perhaps as well to place the general observations under that head.

The chain of the Ardennes is almost entirely composed of this formation, which, on the Rhine, and other places, furnishes considerable quarries of roofing slate.

24. *Sandstone* of transition, an aggregate of small particles rounded by attrition, united generally by a siliceous cement, alternating with clay-slate and gray-wacke shist. This rock has been found to contain the remains of organic matter, and must therefore be considered of Neptunian origin.

This is rather a partial formation, found generally in thin strata, alternating with the transition shist, though it forms in some places west of the Alleghany mountains, in North America, considerable ranges of small hills, and constitutes a great proportion of the rolled pebbles found in rivers which run over the transition formation.

25. *Limestone* of transition, resembling a little the limestone by precipitation of the first order, though not so similar as that of the secondary; and containing, though in small quantities, shells and the remains of other organic matter, which shew it to be of Neptunian origin.

This limestone is mixed with the graywacke, and clay slates, in almost every proportion, from the thinnest shistoze stratification, to the most powerful and solid beds; forming immense blocks free from cracks or fissures; and it is probable, that the small grained statuary marble both of Italy and Greece, belongs to this formation. When this formation touches the compact secondary limestone, without any intervention of graywacke shist or slaty rocks, the passage is gradual and almost

imperceptible, leaving much doubt and difficulty about the place where the line of separation ought to be drawn. It is of all the members of transition formation, the one which most resembles in structure those of the secondary.

26. *Gypsum* of transition, resembling in component parts, though differing a little in structure from, the gypsum of alluvial and secondary: as it alternates and is mixed with clay slate, in which the remains of organic matter has been found, this connects it with the rocks of Neptunian origin.

This is a considerable formation, generally found in mountainous countries; and from the facility with which it is dissolved by water, is in a broken and confused state, often out of its original place, which is perhaps the reason it has been so often supposed to be inclosed in primitive rocks, which the result of all my observations incline me to doubt.

It is probable that all the gypsum in Tuscany belongs to this formation; the powerful bed on the top of mount Cenis, I should think also of the same species. This gypsum having on each side a blue limestone, with dark colored shist alternating with calcspar, it seems to be connected with the transition rocks, as well as the many powerful beds which are found in the valley of Lanz, from Lanz le Bourg to *Aiguebelle.*

The gypsum found in the valley between St. Martins and Sion, in the Switz Alps, is surrounded by what I consider transition rocks; and that perhaps in the valley of Chamouny, and in the pass between Airolo and Desentis, from the nature of surrounding rocks must be classed in gypsum of transition. As these three last mentioned localities are in a line, running nearly with the stratification of the chain of mountains, it is probable that

they are only the remains of an immense bed of gypsum, which might at one time have occupied some part of the space where those passes and valleys are formed.

This gypsum has a small crystalline grain, with little or none of the fibrous or lamellar crystallized gypsum so common in the formations of the secondary class.

27. *Clay slate* of transition. The shistoze formation, containing and alternating with strata which contain impressions of vegetables, and, in some places, of animals, must be considered as of Neptunian origin.

A great variety of rocks, principally of a shistoze structure, are included in this formation. They alternate with shistoze limestone of transition, having small veins of calcspar crossing the strata, the shist often composed of small detached plates of mica, or what has lately been called talc, and in some places small veins of quartz intersecting the strata. It has the exterior form of gneiss, when the thin strata of blue calcareous shist, and plates of calcspar, in segments of unequal thickness, alternate with each other in the direction of the stratification.

Roofing slate generally alternates with this formation; and from its being best known, has contributed, in a great measure, to include the others in the transition class. Being a necessary article for the covering of houses, it has occasioned considerable quarries and excavations to be made in almost every country. In the course of working and splitting the slate, impressions of vegetables, fish, &c. &c. were found, which probably would not have been discovered had the roofing slate, like the other shist, been unfit for the covering of houses; as the mode of decomposition on the sur-

face would have destroyed those impressions, they might have remained for centuries before we could have observed them, and all this shist formation would have been then considered as belonging to the primitive; and as originating before the existence of any organic matter.

May not our wants, compelling us to quarry other rocks, joined to a much more accurate mode of examination, discover the remains of organic matter in rocks until now considered primitive; which might entirely change all the present theories of the formation of the earth, and prove how dependent those conjectural theories are on the smallest discovery that might be made by the attention and observation of a stone-mason?

I found the roofing slate near St. Maria, not far from the gypsum, between Airolo and Disentis, to be a black carbonated transition slate; on the passage of the Fourche; roofing slate containing pyritous impressions of fish, at Blattenburg, half a league from Matt, in the Canton of Glaris; roofing slate, containing shells, near Meyrengen in the Canton of Berne; roofing slate of Angers; the Ardennes; in Wales, in England; in various parts of the transition in the United States of America, &c. and most probably to be found in some part of every considerable formation of transition; though the knowledge and industry of the inhabitants may not have yet applied the slate to any useful purpose, and of course it lies concealed in the mass of other rocks, till now considered of no use, unwrought and unknown.

28. *Anthracite* being a combustible, and found alternating with shist, having vegetable impressions, though rare, must be considered of Neptunian origin. Two kinds of anthracite have been found within the United States of America; one rather

granular, of a grayish color, and slight metallic appearance, containing small veins of quartz; the other blacker and more shining, resembling more the common coal in appearance.

The formation in the United States of America, has been generally attended with a satiny transition slate, bearing impressions of vegetables, a rather hard species of allum slate, and strata of black chalk, as in Spain, which is included likewise in transition slate formation: it has been said to exist in the primitive in some parts of Europe but in no place where I have had occasion to examine the situation of the anthracite have I found primitive rocks covering or overlaying this formation; though in some places they might serve as the foundation to it. I have likewise near Edinburgh, in Hungary, and in France near Tulle, examined the common bituminous coal formation, which was said to alternate, and to be covered, with primitive rocks; but found it only in appearance, from the derangement of the original situation of the strata in both places: agreeably to my observation they were the remains of a coal formation in a primitive valley, which had undergone considerable revolutions, so as to leave only a few dislocated fragments of the former stratification.

29. *Siliceous shist*, (Keiselshieffer) and Jasper, are placed here, from their resemblance to the siliceous precipitations of the secondary class of Neptunian rocks, and alternating with some of the rocks of the transition class.

The leading features of the foregoing formations are, a very great extension both in length and breadth, in proportion to their depth and thickness, dividing into horizontal strata, or at a small inclination, seldom divided by vertical fissures, and continuing through the whole strata without any great change in the structure or external appear-

ance of the substances. This formation may be found to occupy generally between the 20th and 55th degrees of latitude, whilst the primitive may be found to predominate towards the poles.*

May the proper proportion of heat and moisture, necessary to the production of organic matter, in the middle and southern latitudes, be one reason why we find there the formations which contain, and are partly composed of, such matter in great abundance? or the absence of heat towards the poles, be one of the causes why those formations are not found there in the same proportion, but consist principally of the primitive?

While little or none of Asia, Africa, and perhaps not one-third of Europe, and still less of America, have been examined by mineralogists having a knowledge of rocks, one runs the risk of generalizing too much in the present state of our knowledge, and of finding the greater part of future discoveries, contradicting our principles of generalization.

The metallic repositories contained in the rocks of Neptunian origin, have a great resemblance, both in substance and situation, to those found in the primitive class; it is perhaps, one of the strongest features of connection which approximates those two classes, and will be considered along with the rocks of the primitive class.

The volcanic rocks are rather embarrassing, not from the nature of the rocks themselves, which in situation are consistent and uniform, and in texture, and external characters, better marked, uni-

* Should future experience and observation demonstrate that Nature has accumulated the greatest proportion of the secondary formation in the middle and tropical latitudes, and for the same reason continues to heap upon the surface in these latitudes, the matter consolidated by the action of animal and vegetable life; would this not tend to augment the diameter of the globe at those places, and of course give the appearance of flatness to the poles?

ted by stronger features of family connection, than the Neptunian rocks—but from the complicated state of the nomenclature, arising out of the dispute about their origin. The generic name *lava*, simplifies the nomenclature adopted by the Volcanists, while the Neptunians admitting of few lavas, except those ejected from volcanoes at present in action, have been forced to give other names to the great variety of rocks produced by volcanoes now extinct, or united by strong analogy to the same origin.

CLASS II.

ORDER I.

Rocks of Volcanic origin.

Thrown out of active volcanoes, the origin of whose formation rests on the evidence of our senses.

There are two modes of examining rocks; one, the investigation of their external appearance, and internal structure, which can be accomplished with hand specimens in a cabinet, and belongs properly to mineralogy; the other is the tracing, upon an extensive scale, the relative position of their beds, whether stratified or divided by vertical fissures; if stratified, whether horizontal or at a dip from the horizon, whether the stratification is regular, occupying large fields of extensive countries, or consisting of detached insulated masses, with vertical fissures, partially scattered on the surface of all the other formations, &c.: this perhaps, belongs to geology, and cannot be studied in the cabinet, but requires much practice in the mountains, hammer in hand.

Lavas thrown out from recent volcanoes are various in their fractures; they contain a number

of insulated crystals; and are composed of a variety of different substances; but have one general distinguishing mark, which runs through the whole, and separates them from rocks of Neptunian origin: this mark, is a roughness and asperity in the structure, owing to their half vitrification, and numberless small pores which they contain; this asperity is softened down by age. Old lavas by infiltration, and absorption of water, with the different substances that accompany it, put on a milder and more unctuous structure, and approach nearer the structure of Neptunian rocks.

Currents of lava flowing from the crater as a centre, towards the circumference, are irregular and abrupt in their relative position with surrounding formations; they have no marks of stratification; when divided it is always by vertical fissures; they are found in detached masses or long ridges, of a considerable thickness in proportion to their width; occupying the inequalities of the surface of all formations whereon they lie, and with which they seem to have nothing in common.

Mineralogists have divided the lavas into different species, according to the different substances which compose the mass of the rock; others have classed them according to the different crystals they contain; but these distinctions in no wise affect their origin, and are foreign to the present subject.

The total absence of metallic veins in lavas, forms a mark of distinction between the two origins. Some iron has been found disseminated in the cavities, in the form of specular iron-ore, which is evidently formed by evaporation, but in small quantities scattered through the porous lavas.

Submarine eruptions are common, as is proved by the number of islands thrown up under the evidence of our senses; and the still greater number

of islands that apparently, and by direct analogy, have been produced by submarine eruptions, though the periods of their formation were long before the date of our records. It is under such circumstances that the alternation of the Neptunian and Volcanic formations most frequently takes place, as in the islands of Dominiqua, St. Christopher, and St. Eustatia, in the West Indies; the fish and shells found in the lava in the Vincentin, &c. so that the finding of a bed of shell limestone between two currents of lava, would be agreeable to the laws of nature, and no deviation from the common order of things.

Scoria is a kind of vitreous scum that floats on the surface of all lavas, and is often ejected, before an eruption, by the elastic fluids, and falls and mixes with the cinders. The presence of scoria in extinct volcanoes is admitted by most Neptunians as a proof of the action of fire, but its presence is, from the nature of the substance, not of long duration; the rain-water carries it off, and scatters it over the lower places and vallies, where the operation of time reduces it to an excellent rich soil, when it of course loses all marks of volcanic origin.

Time, with the assistance of heat and moisture, decomposes and changes all the distinguishing marks of rocks of Volcanic origin, and recomposes them into the form and structure of rocks of Neptunian origin; but the more frequently rocks of Neptunian origin are decomposed and recomposed, the stronger are the characters of their origin, so that we cannot be deceived by the present appearance of Neptunian rocks, when tracing them up to their original form; but we are liable to mistake rocks that were originally of Volcanic origin before their decomposition, for rocks of the Neptunian, after the change which time and the ele-

ments have made in them. It is easy to conceive a large field of Volcanic rocks totally reduced to Neptunian by the daily operation of the elements; but a field of Neptunian rocks cannot be changed into Volcanic but by fire. The productions by fire are partial, violent, and at first strongly marked, but liable to lose their characters by the daily and hourly operations of the elements.

Mud lava may perhaps be considered as the last efforts of an expiring volcano, when the combustible is nearly burned out, and the immense caverns, whence were ejected the great currents of lava, come to be filled with water, which gradually decomposing the bottoms and sides turns them into clay and mud.

The application of a sufficient quantity of heat to the water in those caverns, so as to turn it into steam or elastic vapour, may perhaps, be the most reasonable manner of accounting for these eruptions which have from time to time overrun whole countries; but the evidence of their origin must rest either on tradition, or the evidence of our senses: for when once the circumstance of their being ejected from the bowels of the mountain is forgotten, there is no mark on the mud itself to distinguish it from mud deposited by a river, the sea, or any other aqueous agent.

Cinders are a volcanic production that are ejected in all stages of the eruption, like showers, and fall on the earth in strata of different colours, imitating the stratification of Neptunian rocks, as at Orlot, in Spain; but when thrown out in mass, and like a current, they generally indicate that the volcano is about to finish and that the combustible matter is nearly exhausted: as at St. Vincent, and the other small volcanic islands of the West Indies. These cinder eruptions throw out large quantities of rocks half roasted, that have all the

appearance of primitive rocks; some like granites, others like gneiss, and some hornblend and feldspar rocks, neatly crystallized and brilliant, having all the feldspar half vitreous. There is a great similarity, both in structure and appearance, in the roasted rocks, thrown out with the cinders, in the environs of Rome, and those thrown by different eruptions in the West Indies. When such beds of cinders have lain long exposed to the weather, the greatest part wash away, and the remainder become earthy and lose most of the characters of volcanic productions.

Pumicestone is of volcanic origin, produced by the interference of a medium that is a good conductor of heat, such as water; it is generally found on islands; and attends most submarine eruptions. Most of the pumice of commerce comes from the islands of Lipari; it is likewise abundant in the West India islands; and generally near the sea. The rapid cooling of the melted glass, before the elastic fluids are disengaged, seems to be necessary to the formation of pumicestone. In an extensive field of volcanic productions at the Cape du Gat, in Spain, the pumice joins to the pearlstone and obsidian, and appears to be the outside, while the pearlstone and obsidian occupy the interior, and have been subject to a more gradual cooling. At the Cape du Gat, vast excavations were made by the Romans, in search of gold according to the opinions of the inhabitants, but really for the alum rock, similar to the alum rock of Tolfa, at Sulfaterra, near Naples, and in all the volcanic islands of the West Indies, formed by the lava, bleached by the sulphuric acid.

The seat of Volcanic fire is not known; how deep it may originate below the primitive, is exceedingly uncertain; or whether its beginning, and progress, is limited to the primitive rocks, and

those above them. Experience teaches us, that volcanoes are often in the primitive, or at no great distance from it; and that the greatest part of the substances ejected in a roasted state, and without marks of fusion, are similar to primitive rocks. It is not probable, that any new substances have been ejected by volcanoes, which were not previously found in some of the other classes of rocks, particulary in the primitive. Sulphur is the combustible substance, generally found in and near volcanoes. It is probable that neither sulphur, nor any other combustible substance, has been yet found in the lowest granite; from which it would appear, that the fire of Volcanoes commences either above or below the mass of granite.

It is probable that two thirds of the volcanoes that we know of, are upon islands; many of which have been thrown up from the bottom of the ocean, and consist entirely of volcanic rocks: from which it is probable, that the vicinity of the sea is favourable to the commencement of volcanic combustion.

ORDER II.

Where the fire has not existed within the reach of history, but where the nature and component parts, the relative situation, &c, is little different from the active volcanoes, having the remains of craters, cements, scoria, &c. &c. placed in the same relative situation; the currents of lava radiating from the crater, and covering all the classes of rocks, and filling up all the inequalities the currents meet with. Between this arrangement, and that of an active volcano, there is a direct and perfect analogy.

In comparing old lavas with those that have recently been thrown out of a crater, considerable

allowance ought to be made for the great change that has taken place in the former, by the action of air and water, and the substances that accompany them. The constant filtering of the water, through all the pores of the lava, takes off its asperity and roughness, while the pores themselves are filled by depositions of the various substances held in solution by the water: at the same time the water oxides the iron in the lava, and changes it into a dull earthy fracture; all which changes disguise and mask the true character of the rock, and are liable to deceive observation, if it is partial and limited to a small extent of country.

It is the nature of volcanic rocks to be in detached pieces, and particularly after time and decomposition have worn away all the scoria, cinders, porous lavas, &c. when the most solid part of a current of lava becomes insulated at a considerable distance from the other detached masses of rocks of a similar origin. Great care ought to be taken to fill up the chasm that time has made in the continuity of the rocks, before we can decide with propriety.

The fields of extinct volcanoes, that I have had an opportunity of examining, were as similar as possible in their component parts, and relative position: an extensive field round Orlot—near Humila, and at the Cape du Gat in Spain—round Rome—between Rome and Florence, and in the Vincintin, in Italy—in Auvergne, in France—round Andernac on the Rhine—at Cassel, in Germany—all of which leave no doubt in my mind of their volcanic origin. In all of them I found abundance of basalt; in some of them the greatest part of the solid lavas were in form of basalt. The Austrian police prevented me twice from examining Hungary, but I have seen repeated collections of the rocks of that country, and could scarcely

distinguish them from those collected from around Naples. How the origin of basalt could be doubtful with the Wernerians, can only be accounted for, by Werner having at first put the detached masses of basalt, found in Saxony, into the Neptunian origin, and that his disciples have since persevered in the arrangement.

In geological descriptions, it is probable that much confusion has arisen from mistaking veins for beds. A bed is a stratum in a stratified rock; but rocks that are not stratified cannot be said to contain beds: they may have some of their vertical fissures filled with different substances, or a crack or split in the rock filled up by infiltration, but that I should suppose would be, properly speaking, a vein. Basalt is not stratified, nor is the greatest part of what the Wernerians call the newest flœtz trap stratified; therefore these rocks cannot be said to contain beds, but only fissures, or splits and cracks, filled up with different substances, which can have no relation with the origin of the rock itself.

The volcanic islands of the West Indies, such as Grenada, St. Vincent, St. Lucia, Martiniqua, Dominiqua, Guadaloupe, Monsterrat, Nevis, St. Christopher, St. Eustacia, and Saba, have but little basalt exposed to view: and in that resemble active volcanoes, where the cinders, scoria, and other porous rocks, have not had time to wear away, or the rivers to cut canals through their currents of lava, so as to expose the solid interior lava to our examination.

In ancient, as in the recent lava, there is no appearance of metallic veins, or other metalliferous substances; and it indiscriminately covers every class of rocks, not unfrequently even vegetable mould, filling up all the inequalities of the surface over which it runs. This is a strong mark of dif-

ference between the Volcanic and Neptunian origin; for the Neptunian being a deposition from water, by the force of gravitation, would form a bed of the same thickness upon the whole surface, and leave the inequalities of the surface the same as before the deposition.

ORDER III.

Where the rocks resemble much, volcanic rocks, but are deficient in their relative situations, having no remains of scoria, craters, cinders, &c. &c. but are in scattered and detached masses. Here the analogy is not so direct as in the second order, though nearer it than any of the Neptunian origin. The greatest part of this order is basalt, in detached masses, or long ridges; occupying in general the tops of small hills, having no resemblance or relation to the surrounding strata; and covering indiscriminately all the classes of rocks as well as every species of alluvial; in some places it has even overlaid vegetable mould: in all which characters it agrees with the rocks of recent volcanoes. In its component parts, and imbedded crystals, it is equally resembling, having crystals of peridot, and pyroxine, disseminated in it, like the recent lavas of Mount Vesuvius. As in the lavas of recent Volcanoes, so in this order, there are no metallic veins or deposits found; which seems to be a characteristic difference drawn between the two origins, that cannot be mistaken, and perhaps would form a line of separation sufficiently strong of itself without the aid of any other difference.

Pitchstone, greenstone, pearlstone, porphyry, clinkstone, &c., &c., are names given to the different kinds of rocks found in what Werner calls his newest flœtz trap class: they indifferently cover all

other classes of rocks and alluvial, and as they are generally found in the vicinity of basalt, they must be considered of the same origin. This kind of porphyry has a petrosiliceous base, with crystals of feldspar, not the dull fractured porphyry, with crystals of quartz and feldspar, which generally covers the primitive, though it seldom alternates with it. In this way confusion of names takes place. A Neptunian geologist travels over a country, where the rocks of the newest flœtz trap occur; he finds trap, greenstone, and greenstone traps, porphyries, clinkstone, basalt, &c, &c. A Volcanist travels over the same ground, and he describes it as consisting of different species of lava.

Werner being the first that made any classification of rocks, his disciples of course were the first who made any geological observation; and as they seemed all much interested in putting this class of rocks into the Neptunian origin, they passed slightly over them, and described them by Neptunian names. This may perhaps be one reason why they are not so generally known as other rocks, and why they are to be found in greater abundance on the surface of the earth than was generally supposed. When positive and liberal examination takes the place of that party and systematic spirit, which seems to have no other object in view than the support of a theory purely conjectural, depending on the fancy of the author, and changed and overturned by every new inventor of systems, it is then that the science of geology will make rapid progress, and be ranked according to its real utility.

This class of rocks is scattered over the surface of the globe. I found them in the Crimea; along the south side of the Bohemian mountains; on both sides of the Saxon mountains, but more com-

mon on the south side; near the Rhine at Hohentweiler and Old Brisack; scattered over the country of Thuringia and Hessecastle; occupying the tops of the hills through the greater part of the Vivarais; at Montpellier and Agde in France; at Carthagena in Spain; in patches along the foot of the south side of the Alps, from the valley of Falsa to Lago Majore, &c., &c. On the continent of America, north of the Gulf of Mexico, and east of the Mississippi, none of this formation has yet been found; the nearest to it is the trap, which covers the oldest red sandstone, but it has no basaltic columns, nor does it contain any peridot or pyroxine; and in other respects does not much resemble this class of rocks: though this trap approaches nearer to it, than any other yet found. Neither have any active or extinct volcanoes been found in that country, which is a species of proof in favor of common origin; for if the first and second orders of this class had been found in the United States, and none of the third order, it might have given reason to doubt of their origin; or if the third order had been found, and the first and second orders of this class were wanting, it would have been equally the cause of doubts; but absence of all the three orders, implies the absence of fire, the origin of the three orders.

CLASS III.

Containing rocks that have some distant resemblance both to the rocks originating in water, and in fire, but no distinct analogy to either: whose origin must remain in doubt, depending on simple conjecture.

ORDER I.

Those rocks which conjecture might be disposed to place in the rocks of the Neptunian origin.

Gneiss by its extensive and regular stratification agrees with the relative situation of all Neptunian rocks, but it differs widely in the arrangement and nature of its component parts from any rocks known by actual observation to be of Neptunian origin: it equally differs from those rocks placed by direct analogy in the Neptunian class, though it agrees with the Neptunian in having many and rich metallic veins intersecting it. This perhaps is one of the most prominent marks of distinction between the two origins of fire, and water.

Mica Slate being a species of gneiss, where the layers of feldspar or quartz are so small as not to be distinguished by the eye, must of course follow the origin of the gneiss, as it frequently runs by imperceptible gradations into gneiss, and gneiss into mica slate, making it difficult to decide where the one begins, or the other ends.

Primitive Limestone frequently alternates with gneiss, and resembles the Neptunian origin in its regular and extensive stratification. It does not differ much in its structure from other limestone formed by water, such as the stalactites in caves. It therefore is nearer the rocks of undisputed Neptunian origin than the gneiss; and perhaps only differs in the total absence of the remains of organic matter, with which the limestones of Neptunian origin are filled.

Clay Slate is a rock which corresponds with the rocks of Neptunian origin, in its mode and regularity of stratification: it does not differ very much in its structure and external appearance from the Clay Slate of transition. It having no remains of organic matter in it, while the slates of

undisputed Neptunian origin contain both vegetable and animal remains, prevents the analogy from being direct, and leaves it in doubt.

Serpentine has a regular, and rather extensive stratification, similar to the rocks of Neptunian origin; but in its structure or external appearance, it does not agree with any. It is likewise without the remains of any organic matter, which prevents it being classed by direct analogy with the Neptunian, and leaves it in doubt.

It would appear that Serpentine is more liable than any other rock, to change its form and external character, by the agency of the common elements of rain, &c. &c, and in many instances the changes are visible, where it appears to be sheltered from the weather, as its mutation into every species of asbestus, aminthus, and all the variety of fibrous rocks of the magnesian class. At a place called Bauldissero, at the foot of the Alps, about twelve or fifteen leagues from Turin, a dark colored Serpentine is gradually changing into a carbonate of magnesia; which may by traced through its progress at every step, from the beginning to the end of the process; and there is no visible agent, as great part of the rock is evidently below the influence of the weather. Perhaps some new light might be thrown upon some of nature's agents by a close examination of such changes.

When geological researches are partial, and confined to a small portion of the surface, it is probable that sufficient allowance is not always made for that slow and imperceptible change, which takes place in the structure and external appearance of the rocks, without the aid of any of the known agents, but by a process as yet unknown; not having come within the sphere of our observation we are ignorant of the mode which nature takes to produce such changes.

ORDER II.

Containing those rocks which analogy might be disposed to place in the Volcanic origin.

Hornblend rocks, both greenstones and sienities, as well as the unmixed Hornblends, resemble some species of lava, nearer than they resemble and rock of undisputed Neptunian origin; but in their relative positions, and regularity of extensive stratification, they are similar to those of the Neptunian origin, as well as in having pyrites, and other metallic substances, disseminated; for this reason the analogy is not direct, and the origin must remain doubtful.

Porphyry, in its structure and external appearance, resembles much some lavas, more particularly those of the oldest kind, where the asperity has been worn off, and softened by time: but in its mode of stratification and relative situation, it is similar to the Neptunian origin, therefore the analogy is not direct, and the origin must remain doubtful.

Granite. There are two species of granite; the one in large grains, which occasionally alternates with gneiss, and contains many valuable specimens of minerals, such as the emerald, cymophane, tourmaline, &c. &c.; and the other, a middling grained granite, often with much quartz in it, occurring under all other rocks, in large fields, without any well defined stratification, but divided often by vertical fissures. This last is the granite of which we are speaking; it has more resemblance to some of the feldspatic lavas, than it has to any rock known to be of Neptunian origin. It likewise approaches the volcanic, in relative situation, without any regular stratification. Yet the resemblance does not appear sufficiently strong to amount to direct analogy, and we must there-

fore remain in doubt as to the nature of its origin. This granite is the lowest rock in the arrangement of the globe; through which we never have penetrated; and beyond which we know nothing. It is the nucleus of the earth, from which, and on which, all changes and formations emanate and rest, as an eternal foundation? or is it only a link of those changes, the circle and recurrence of whose action, is lost in the immensity of time? We know nothing; we may form theories and systems without end, and perhaps one system is as good as another; but still we must recur to the humiliating truth, we know nothing.

Between the rocks of the third class, called primitive, and the rocks of the first class of positive Neptunian origin, the great line of distinction is the abundance of remains of animals and vegetables in the first class, and the total absence of them in the third class: this third class is similar to the second class, or volcanic origin, in being without any remains of organic matter.

The first and third classes differ from the second class or volcanic, by being intersected by metallic veins, and repositories of metallic substances; whereas the second class, has no metallic veins, or any metallic deposites in it. The lowest granite approaches to the volcanic, in being without metallic veins, or metallic deposites.

The result of this investigation would appear to be, that all the rocks called alluvial, secondary, and transition, are of Neptunian origin; either by the evidence of our senses, or by a strict and direct analogy with those formed daily under our eyes; that another species of rocks which cover and overlay the former whose origin is either strikingly evident to our senses by the eruptions of active volcanoes, or by a strict and direct analogy, are evidently of the same origin, though the fire

which was the agent of these changes may have been long extinct. Having thus narrowed the ground, we come to the third class or primitive rocks, concerning whose origin neither the evidence of our senses, nor direct analogy, will aid our researches; and we are left to the wide field of imagination, where any individual has a right to exercise his talents in forming theories, or in other words, in making suppositions. The field of fancy is undoubtedly very extensive, where it is not limited by some reference to facts on which theories may be founded; we accordingly find great variety in the methods different authors have taken to form the earth.

At present, the dispute seems to rest between two antagonists, the disciples of water, and those of fire; called Neptunians, and Plutonists or Volcanists. They both found their theories upon the same general supposition; that is, that the earth at the time they began their formation was in a fluid state: but they differ in the agent that nature may have employed to produce that state of fluidity. The Neptunians assert that the whole earth was dissolved in water, and the Volcanists that it was melted into the fluid state by fire. These two theories, as objects of discussion to exercise the talents and imaginations of the literary world, would be innocent and harmless. But when we consider that nine-tenths of geological observations have been collected with a view to support one or the other of the theories, and of course more or less from the true state in which nature placed the substances examined,—and this for the purpose of proving the truth of one nature employs, with the qualities of which we are still unacquainted; and so go to work to examine accurately nature's works; as the only certain mode of becoming acquainted with her laws: this method would, at least, save much precious time, both to writers and readers.

OBSERVATIONS

ON THE

GEOLOGY

OF

THE WEST INDIA ISLANDS,

FROM

BARBADOES TO SANTA CRUZ, INCLUSIVE.

BY

WILLIAM MACLURE.

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GEOLOGY

OF THE

WEST INDIA ISLANDS.

This range of islands may, in a geological point of view, be divided into two distinct parts: one of which, occupying the eastern side, consists of a stratification of transition rocks, partially crowned by secondary, and embraces the islands of Barbadoes, Mariegalante, Grandterre in Guadaloupe, Deseada, Antigua, St. Bartholomew, St. Martin, Anguilla, and Santa Cruz; the other part, consisting of volcanic formations, with a few partial coverings of secondary, occupies the western side of the range, including the Grenadines, St. Vincent, St. Lucia, Martinicco, Dominica, Basseterre in Guadaloupe, Monserrat, Nevis, St. Christopher, St. Eustatia and Saba, where the volcanic formation appears to terminate.

Barbadoes. The northern, southern and western sections of this island consist of rocks, formed of an aggregate of shells and madrepore rocks, mixed with different kinds of corals, being partly consolidated into a mass by the attrition of the water, having the interstices filled by the particles that have been broken, and washed into them, sometimes even losing the marks of their original formation; and partly porous and full of cavities

formed by the washing away of the shells and madrepores, and by the natural shelving of these rocks. This shell limestone is deposited in four or five horizontal strata, rising gradually to the height of eight hundred feet towards the centre of the island, and forming as many *plateaux* as there are strata, resembling, at a distant view, the steps of stairs. Thence to the eastward or windward is the district of Scotland, composed of strata of slate alternating with limestone, and an aggregate cemented with lime, in grains of various sizes, and resembling much the different kinds of gray-wacke slate, dipping to the east, northerly, and running to the north, westerly; having every appearance of being the transition rock on which the madrepores and corals had built their cells.

Mariegalante, *Grandterre* in Guadaloupe, and *Deseada*, are all formed of the madrepore rock, in horizontal strata, resembling the same formation in Barbadoes, the strata being elevated, one above another, and forming a plateau or table of land, at the summit of each, but not rising so high as in Barbadoes. Grandterre in Guadaloupe has this formation, exhibiting more the appearance of undulations, with gentle ascents and declivities, containing some small streams and marshes, which would rather encourage the supposition that it rests on a volcanic basis, and is therefore more liable to have its rocks deranged from their present natural horizontal position.

Antigua. This island not having been visited by the writer, he must take its description from the specimens brought from it, by which it may be concluded, that it is similar, in some of its geological traits, to the island of Barbadoes; having the same formation of madrepore rocks, some of which are converted into silex in the form of agates, &c.; which are valued, as beautiful specimens, by

the curious. A part of the island consists of a stratified rock, in the form of a green schist, crossing the island from north to south, in a zone of three or four miles width, affording the inhabitants a useful building stone. The southern side of the island is rugged and mountainous, and is described as being volcanic.

St. Bartholomew. The formation throughout this island is evidently stratified, though in great confusion, (the word stratified is here used in contradistinction to volcanic) the strata running in a direction a little to the west of north, and dipping generally to the eastward, as far as could be ascertained from the disturbed and irregular position of the broken rocks. These rocks are found to consist of three or four species of limestone, two of them containing shells; some aggregates, which are cemented with limestone, and present much the appearance of transition formation; several species of hornblend rock, a little crystalline; amygdaloid, containing small nodules of *calcaire* and zeolite, or almonds, which, when the stone is fresh broken, are undistinguishable from the mass, and discover their difference only when in a state of decomposition; a soft argillaceous mass, with spots of green, resembling the green earth of Verona; porphyry, with crystals of quartz and feldspar, imbedded in a red argillaceous base, &c., all of them alternating one with another, occasionally, and assuming the appearance of a transition formation. But the various aspects which these rocks present, and the different stages of decomposition in which they are found, and in which they differ much from the rocks of a continent, or of northern climates, render it extremely difficult to determine which part may be secondary, and which transition.

St. Martin and *Anguilla*, are two small stratified islands, on a line with St. Bartholomew, and consisting of a similar formation.

The island of St. Thomas may also be classed in this range. It is stratified, though in much confusion, and so deranged as to render it difficult to ascertain the general direction, which appears to be from north-west to south-east, dipping easterly. The rocks consist of a variety of aggregates, resembling the transition, some of which when fresh have the appearance of hornblend rocks, but when beginning to decompose, the aggregate appears, with a few plates of a black crystalline rock like hornblend. I found a yellowish brown quartzy aggregate, resembling a rock, in the transition, at the Lehigh Falls in Pennsylvania.

Santa Cruz. This island, though included in our first division, agrees rather with the direction of the volcanic islands; it appears, however, that the volcanic formation ceases at Saba, and that Santa Cruz is composed of madrepore rocks at the west, and, on the eastern side, of rocks similar to those of St. Thomas and St. Bartholomew. The west end and the middle of the island, are low, and covered with a shell limestone and madrepore rock. The foundation on which this rock reposes is a stratum that retains water, and may be a compact limestone, as the bases of many of the little hills rest on solid limestone. The east end is composed of different kinds of limestone, alternating with amygdaloid, hornblend rock and porphyry, like the rocks of St. Bartholomew; it is likewise hilly and broken, being stratified in a direction nearly north and south.

All the islands that have been described have a striking similarity both in their structure and the nature of their materials; those that are partly or wholly covered with the horizontal shell limestone, or madrepore rocks, are exactly the same; those partly or wholly formed of stratified rocks, consist of rocks more than half of which are limestone, or

have considerable quantities of lime in them, and the remainder of the rocks differ very little; they have nearly the same dip and direction; have a strong characteristic mark of belonging to the transition class; though from their deranged state, and the peculiar mode of their decomposition, they differ a little in their appearance from the transition rocks of Europe, for the limestone is remarkably hard, dry and brittle, breaking into sharp pieces, which sound like a bell, when struck with a hammer: this may, perhaps, be the effect of the constant heat of the climate. The different appearance which these rocks assume, when in a state of decomposition, from those of northern latitudes, may in part be attributed to the climate, and partly to the same cause which produced the great confusion in which they are now found, particularly, if that cause raised them from the bottom of the ocean, and exposed them to the influence of a perpetual sun. But this, like every cause which we cannot discover, must remain only problematical; for nature has so many modes of operating, and we are as yet acquainted with so small a number of them, that our speculations, beyond what we actually know, can at the best but actually reach to probable conjecture.

The Grenadines. This group of islands is the commencement of the second or western range; we sailed through them without stopping, so that their geological character must be taken from their general appearance, which was completely volcanic, having rocks rising perpendicularly out of the ocean, one of which is called, from its form, the organ rock, being composed of columns of basalt. The rocks are in general rugged, and so deranged that their volcanic character could not be mistaken.

St. Vincent, like all the other volcanic islands, is composed of a mixture of lava and cinders, in

all proportions. South of Kingston there appears to be more solid and porous lava, and less cinders, than at the north. The Bay of Kingston has the appearance of being the remains of an ancient crater, the beds of lava inclining irregularly from the centre, at a considerable dip, as if they had been ejected from it. On every side, the rocks are aggregates of various kinds of roasted stones, cemented with cinders, and small atoms of scoria; and though many of the rolled rocks neither bear strong marks of fusion, nor resemble much recent lavas, yet they all have a family feature, and must be considered of volcanic origin. A substance like hornblend, with feldspar imbedded in it, forms the principal part of these rocks, which vary in colour, from nearly black to gray, the feldspar being generally crystallized, and frequently diaphanous, passing through the porous or scorious rocks without indications of having undergone much change. There are two principal modes by which the production of cinders or ashes may be accounted for: they may be thrown from the crater of a volcano during an irruption of lava, and in that case they consist of small pieces of scoria, pumice, &c. and are placed in strata of various thicknesses and colours, as if deposited by water; or they may be ejected from volcanoes nearly exhausted, mixed with water and rocks, forming large beds or currents, of an aggregate, which is in time cemented, and wears the appearance of a brechia. A third mode is, perhaps, the irruption of lava into the sea, at the commencement of submarine volcanoes, when by means of the sudden cooling, the melted lava might crumble into small angular sand, and form beds of cinders. From Kingston to the north end of the island, the same alteration of cinders and solid lava obtains, forming steep precipices, and narrow vallies, the wearing and exca-

vation of which, by the mountain torrents, is facilitated by the prevalence of the cinders, which increase as you approach the *Soufriere*, a name given, in the West Indies, to spots which indicate the remains of a subsiding volcano, and whence hot sulphureous vapours are ejected through *fumerols*, depositing sulphur, and bleaching the surrounding rocks into alum-stone, as at Solfa-terra near Naples.

The fumerols of this Soufriere are at present extinguished, perhaps by the last eruption of cinders in 1812, when the crater threw a mixture of water, rocks and cinders, in a state approaching to ignition, resembling a current of lava; burning the woods, and filling the channels of the little rivers that descend the mountain, rising sometimes to the height of three or four hundred feet.

This eruption consisted of a great quantity of angular sand, the broken masses of roasted and vitrified rocks being mixed with loose angular pieces of all sizes, brittle, and crumbling under the hammer. These imbedded rocks are, 1st. A rock resembling a small and middling sized grained granite, roasted, with diaphanous feldspar.—2d. A gray rock, in plates, like gneiss, but much altered by the fire. 3d. A feldspar and hornblend rock, the feldspar chrystallized and diaphanous, with the appearance of having been roasted.—4th. A hornblend rock, crystalline, having a roasted appearance. 5th. A dark coloured rock, with a conchoidal, even, vitreous fracture, containing crystals of feldspar, some pieces so vitreous as to resemble pitch stone, and porphyry running through all the gradations from a gray rock, scarcely vitrified, to a total vitrification, and thence to a porous scoria, not unlike pumice, with transparent crystals of feldspar, taking a deeper tinge of black in proportion to the degree of vitrification. 6th. A

bluish rock with feldspar, and some black crystals, having all the appearance of compact lava. If one supposes that volcanic action tends to form large cavities under the places whence the lava, &c. issues, and that one, or more, of these cavities, where the combustible materials are exhausted, becomes filled with water, while other cavities, where these materials still remain, are filled with lava, &c. it would appear only necessary to unite the contents of two such caverns, to produce all the effects of an eruption of cinders.

St. Lucia I passed, and only observed it from the sea. It has the appearance of being rugged and steep, with few vallies, and perhaps not the same proportion of cinders as the other islands. It has an extensive soufriere at the foot of two sharp conical hills.

Martinico. On the south side of the bay of Port Royal, at Lamentine and point De Bourg, there is a compact rock, dividing like trap, and decomposing into balls, which fall into a strong red clay, making an excellent soil; it rests upon a bed of cinders, and assumes in some places the form of basaltic columns.

About Port Royal, and the hill to the north of it, there is a current of solid lava, which has formed the north side of the bay, decomposing into balls, and forming a strong soil.

From point Negro to St. Peters the coast consists principally of cinders, mixed with lava rocks. Under the fort at the south end of St. Peters, and near the Botanic Garden on the north side, there appears a mass of the same rock as occurs at Port Royal, approaching the basaltic form, and is full of vitreous crystals of feldspar.

The region lying across the island from St. Peters to Bass-point, is composed, wholly to the summit of the land, of cinders and pumice, with vege-

table earth lying between the beds of cinders, alternating two or three times. Descending to the windward part of the island, the cinders are found mixed with detached pieces of compact lava, and other rocks, with large blocks of pumice, till you come to the flat country, which is covered with cinders. It is natural to suppose that the greatest part of the light substances, such as cinders, pumice stones, &c. should go to leeward; yet in the eruption of St. Vincent, in 1812, very fine cinders fell on the decks of vessels three or four hundred miles to windward, supposed to have been carried by a counter current of air, in the upper regions of the atmosphere.

Dominica is in general composed of cinders, with rolled and detached pieces of lava, pumice, &c. disseminated so as to form a kind of puddingstone, containing five times more of the cement than of the detached pieces. Where compact lava appears, it is in masses, seldom in currents, and generally covering the cinders, and is also covered by them.

The soufriere is in the bottom of a bay, at the south end of the island, and has all the appearance of being the remains of an ancient crater: it is extensive, and furnishes at times both sulphur and alum, the quantity of alum rocks being considerable. There are other fumerols in the interior of the island, which might furnish alum and sulphur.

On the top of the mountain, as you cross the island, there is a lake, having all the appearance of being an old crater, about which the quantity of loose stones is greater, and of cinders less, than on the coast.

A bed of coral and madrepore limestone, with shells, lies horizontally on a bed of cinders, about two or three hundred feet above the level of the

sea, at Rousseau, and is covered with cinders to a considerable height.

Basseterre in Guadaloupe. On landing at St. Rose, at the north end, the red clay occurs as at Lamentine in Martinico, and is the result of the decomposition of the same compact blue basaltic rock, which appears to prevail over all the low country, dividing Grandterre from Basseterre. This blue rock is placed on a bed of cinders, and takes the form of an irregular basalt.

From St. Rose to Delahay, along the coast, the head land appears of solid rocks, like currents of lava, separated by narrow sandy vallies, the sand being partly white and calcareous, formed by the trituration of shells; and partly black and ferruginous crystalline, from the decomposition of solid lava: this ferruginous sand is found in all volcanic countries, and frequently is a distinguished characteristic of volcanic regions. At a head land, about one league north of Pigeon island, called Malendure, there occurs a current of red cinders, filled with small prisms of red stilbite, and having loose pieces of lava mixed, containing also the red stilbite, two of them, viz. Vesuvius and this, are undoubtedly volcanic, the other, the valley of Falsa, in the Triol, has been supposed to be of Neptunian origin by the Wernerians. Along the coast of Basseterre is found a mixture of cinders and lava, but more solid lava in currents, than in the other islands.

About six leagues to the top of the cone, where the crater had been, and where the soufriere is now, I found a chasm or crack, in the mountain, which had all the appearance of having been once a crater, but which had been closed by some convulsion, where, by the removal of the middle, the sides had been impelled together with such force, as to break up the walls, and leave the whole in

the greatest confusion. The fumerols are on the side of this crack, without any accumulation of sulphur, or alum rock, for these substances fall into the crack as fast as they are formed. The scenery is exceedingly rugged and wild; the rocks broken in immensely large masses, and irregularly thrown about in every direction. At the northern extremity of this crack lies what is called the cave, whence there issued, about fifteen or twenty years ago, a flood of water and rocks, which ran down the valley, at present called the valley of Faujas, in the utmost disorder. I am inclined to think that water only came from the crack, and that it ran over the mountain, sweeping in its course all the small stones and cinders, leaving those that were too large to be moved. This eruption of water was cool, and without any apparent connection with heat, though it was most probably ejected by the force of some elastic fluid.

Montserrat. I passed close to the leeward side of the island of Montserrat, but did not land. The south side had an appearance of being partly composed of solid rock, and the rest of the island might be supposed to be constituted of cinders mixed with loose rocks, as it consists of one mountain, the sides of which are furrowed by the rain, gently, and not in precipices, as would have been the case had there been many currents of solid lava; which circumstance, with the flatness of the coast, and the gradual ascent of the mountain, would seem to indicate a great proportion of cinders.

Nevis consists of one mountain in the middle, a truncated cone, I suppose about two thousand feet high; and one small elevation to the south, called Saddle-Hill, and another to the north, called Round-Hill; the rest of the island is a gradual descent from these three hills to the sea. It is composed of large masses of rocks, in beds of cinders, gray,

red, and black, of various degrees of solidity, from the pumice to the compact lava; the black crystals I take to be augite, or perhaps what Werner calls the basaltic hornblend, of the Cape de Gate in Spain, many of the rocks being like those found at that place. The white or glassy I take to be feldspar, which, with a black substance resembling hornblend, constitutes a great proportion of the rocks of the volcanic islands in the West Indies. The nodules which are found occur, more frequently in the centre of other rocks, they are of a small compact grain like greenstone and not unlike those rounded pieces found in granite.

About one mile and a half south-east of Charleston, there is a soufriere almost extinct, which occupies about two or three acres of level spot. One mile below, there is a hot spring, the water of which rises to one hundred and ten degress of Fahrenheit, and is used as a medical bath; and on the edge of the sea, about half a mile distant, the heat of the earth is sufficient to make the water boil. To the north of Charleston there are likewise soufriers, and there can be little doubt that on all the islands, there have been a number of soufrieres which are now extinct and wasted away.

St. Christopher. This island, near Basseterre, consists of beds of black, red, and gray cinders, varying in thickness from two inches to many feet, containing black and white crystals, resembling those found in the last cinder eruption of St. Vincent. The sand on the bay of Basseterre is mostly of the black iron kind, with scarcely any of the broken shells or madrepore rock. Along the coast to Old-Road, the formation is of cinders, with few detached rocks, and the same from Old-Road to Brimstone-Hill.

Brimstone-Hill is a stratification of madrepore limestone, containing shells, at an angle of upwards

of fifty degress from the horizon, reposing upon a bed of volcanic cinders, and partly covered by volcanic eruptions, making a fine specimen of the alternation of the Neptunian and volcanic formations, which, for ought we know, may be repeated twenty or thirty times in the foundation of these islands, as every current of lava that runs into the sea is liable to be covered with corals, madrepores, &c. and afterwards recovered with lava, until it comes above the surface of the sea.

On the south end, above Sandy-Point, there is more pumice stone, and at a point a little north, there appear to be solid masses of compact rock, which look like currents of lava. From Sandy-Point to Deep-Bay, the rocks which occur are those mixed with cinders of a black color, and full of glassy or transparent crystals.

St. Eustatia is formed of two hills that appear to have been both craters of volcanoes; the western one is more ancient and is filled up with earth, &c., the eastern one is higher and appears to be more recent, the crater being only partially filled. The space between these two hills is filled with cinders, forming a plain with a bay on each side; the one to the leeward is the harbor, on the edge of which stands the town.

On the south-east side of the large hill towards St. Christopher, there is a stratification of madrepore limestone alternating with beds of shells, similar to those found at present in the sea. The whole of his marine desposition dips to the south-west, at an angle of upwards of forty-five degrees from the horizon, resting upon a bed of cinders, full of pumice and other volcanic rocks, and is immediately covered by a bed of madrepore, and cinders, mixed together, with blocks of volcanic rocks so disseminated that there can be no doubt of the volcanic origin of the substance above and below

the madrepore rock, which may be from five to six hundred yards thick. Part of this madrepore rock is changing into silex, having the part that surrounded the animal already converted into chalcedony. A considerable quantity of gypsum is found near the same place, in a crystalline state.

Saba. This little island seems to finish the volcanic formation, and consists of one mountain, rather rougher and more rugged than St. Eustatia, but apparently of nearly the same kind of rocks.

The foregoing description of the volcanic islands may perhaps authorize the following general remarks.

1st. That there is a great similarity in the substances ejected, which are marked by a family feature running through all the rocks, cinders, &c., of the different islands; and it is to be observed that the proportion of cinders, pumice, and other light substances, is much greater than of solid lavas, which are but thinly scattered; also that the cinders are always the lowest stratum, on a level with the sea, and the masses of solid lava near the level, repose on a bed of cinders, in every place where I had access to *them.*

2d. The madrepore and coral rocks, mixed with shells, partly similar to those found at present in the sea, are found in many places alternating with the cinders, and other volcanic rocks, presenting much the appearance of the whole having been ejected from the bottom of the ocean.

3d. The direction of the islands, running from north to south, a little easterly, corresponds with the direction of the strata of those stratified islands, lying to the eastward: such as Barbadoes, St. Bartholomew, &c., which should seem to support the supposition, that the seat of combustion occupies a stratified substance, running parallel to the general stratification of the surrounding rocks.

4th. In all the islands there are one or more soufrieres, all of which form alum rocks, and deposite sulphur, proving that sulphur is one of the ingredients that support the combustion, and perhaps giving strength to the supposition, that whatever may have been the original cause of the combustion, that cause is uniform, and the same through all the islands.

5th. In the eruption of cinders, lately ejected, there was a great quantity of stones thrown out, exhibiting no appearance of having ever been in a state of fusion, but only roasted by a considerable heat; most of these rocks have every appearance of belonging to the primitive class, by their crystalline structure, and the position of their component parts. From which remarks it would appear reasonable that the following conjectures may be hazarded.

1st. That the islands were probably thrown up from the bottom of the ocean.

2d. That the seat of combustion is more probably in a substance stratified, and that sulphur is one of the combustible ingredients.

3d. That the substance so stratified is most probably the primitive, and that consequently the combustion is in the primitive region covered by the transition, which forms the islands of the eastern group.